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LEAD-BASED PAINT ABATEMENT AND REPAIR AND MAINTENANCE STUDY IN BALTIMORE:

FINDINGS BASED ON TWO YEARS OF FOLLOW-UP

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CONTRIBUTING ORGANIZATIONS AND ACKNOWLEDGMENTS

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Kennedy Krieger Research Institute (KKRI)

KKRI was responsible for the overall design and conduct of this study, including the field, laboratory and data analysis activities, and the preparation of this report. The KKRI investigators were Mark R. Farfel, Sc.D., Project Director and J. Julian Chisolm, Jr., M.D. The Johns Hopkins University co-investigators were Peter S.J. Lees, Ph.D., Department of Environmental Health Sciences, and Charles Rohde, Ph.D., Department of Biostatistics. Study staff included William Derbyshire, Project Manager; Brian C. Rooney, Data Analyst; Desmond I. Bannon, Trace Metals Laboratory Supervisor; Pat Tracey, Outreach Coordinator; and Ken Watts, R&M QC Officer. Field staff were Eula Kemmer, Earnestine Powell, Tammy Smith, and Marc Talley. Laboratory staff included Michael Burns, Mavis Harby, Lori Losh, Catherine Murashchik, and Becky Zapf.

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Maryland Department of Housing and Community Development (DHCD)

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U.S. Environmental Protection Agency (EPA)

The U.S. EPA was responsible for managing the study, for providing technical oversight, guidance and direction, and for overseeing the peer review and finalization of the report. The EPA Project Leader was Benjamin S. Lim. The EPA Work Assignment Managers were Benjamin S. Lim and Brad Schultz. The EPA Project Officers were Benjamin S. Lim, Phil Robinson and Jill Hacker.

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EXECUTIVE SUMMARY

In recent years, there has been growing interest in the use of interim measures to temporarily control the problem of extensive residential lead-based paint hazards in U.S. housing in a cost-effective manner. Title X of the Housing and Community Development Act of 1992 (P.L. 102-550) defined interim controls as “a set of measures designed to reduce temporarily human exposure or likely exposure to lead-based paint hazards, including specialized cleaning, repairs, maintenance, painting, temporary containment, ongoing monitoring of lead-based paint hazards or potential hazards and the establishment of management and resident education programs.” The 1995 *Guidelines for the Evaluation and Control of Lead-Based Paint Hazards in Housing* issued by the U.S. Department of Housing and Urban Development (HUD) provide detailed information on interim control practices. However, little is known about the short- and long-term effectiveness of these approaches in terms of reducing lead in dust and in children’s blood.

This report presents two years of follow-up of the Lead-Based Paint Abatement and Repair & Maintenance (R&M) Study in Baltimore. An earlier report presented results for the first year of follow-up (EPA, 1997). The study was designed to characterize and compare the short-term (two months to six months) and longer-term (12 months to 24 months) effectiveness of three levels of interim control interventions (R&M I-III) in structurally sound housing where children were at risk of exposure to lead in settled house dust and paint. At the time of this study, owners were not required to reduce lead exposure in their rental properties prior to children becoming poisoned. Thus, study houses received R&M interventions that they were not likely to have gotten otherwise. Funds for R&M work provided by the Maryland Department of Housing and Community Development were capped at $1,650 for R&M I, $3,500 for R&M II, and $7,000 for R&M III.

R&M I included wet scraping of peeling and flaking lead-based paint on interior surfaces; limited repainting of scraped surfaces; wet cleaning with a trisodium phosphate (TSP) detergent and vacuuming with a high efficiency particulate air (HEPA) vacuum to the extent possible in an occupied house; the provision of an entryway mat and information to occupants; and stabilization of lead-based paint on exterior surfaces to the extent possible, given the budget cap. R&M II included two key additional elements: use of sealants and paints to make floors smoother and more easily cleanable and in-place window and door treatments to reduce abrasion of lead-painted surfaces. R&M III added window replacement and encapsulation of exterior window trim with aluminum coverings as the primary window treatment, encapsulation of exterior door trim with aluminum, and the use of coverings (*e.g.*, vinyl tile) on some floors and stairs to make them smooth and more easily cleanable. Additionally, all R&M households received cleaning kits for their own cleaning efforts. During follow-up, families were informed by letter of the results of dust lead and blood lead tests from each campaign (Appendix A).

For this reason, the study intervention was a combination of R&M work and the provision of information to families on a periodic basis. Further, as required by Maryland law, all blood lead results were reported to the Maryland Childhood Blood Lead Registry which in turn reported the results to the Baltimore City Health Department for follow-up and case management. Thus, this study add to, but did not replace usual medical care.

The study had two control groups: urban houses built after 1979, and presumably free of lead-based paint, and previously abated houses which had received comprehensive abatement between May 1988 and February 1991. For ethical reasons, the study did not include a non-intervention control group of houses that contained lead-based paint hazards.

The study population consisted of Baltimore households with at least one participating child that occupied or moved into study houses owned by collaborating rental property owners and a non-profit housing organization. All households were African-American and reflected the demographic composition of neighborhoods where collaborating owners managed their properties. At the outset, mean ages of study children ranged from 25 to 34 months across groups, and their geometric mean blood lead concentrations were 9 µg/dL in R&M I, 13 µg/dL in R&M II, 14 µg/dL in R&M III, and 12 µg/dL in the previously abated houses. Based on reported housing histories, children in these four groups had spent most or all of their lives in older low-income rental housing and thus had been at risk of exposure to lead in dust and paint. By contrast, most children in the modern urban group had lived in the same house since birth, and all of them had baseline blood lead concentrations less than or equal to the CDC's blood level of concern (10 µg/dL). Their baseline geometric mean blood lead concentration was 3 µg/dL, a value similar to that estimated for U.S. children in this age range (2.7 µg/dL) but lower than the estimate for U.S. non-Hispanic black children 12 months to 60 months of age (4.3 µg/dL) (CDC, 1997b).

Study objectives related to enrollment, laboratory performance, data quality and data completeness were met. The main findings based on dust lead loadings and concentrations, dust loadings, and children's blood lead concentrations from the five study groups collected before and immediately after intervention, as well as during the two-, six-, 12-, 18-, and 24-month post-intervention data collection campaigns are summarized below.

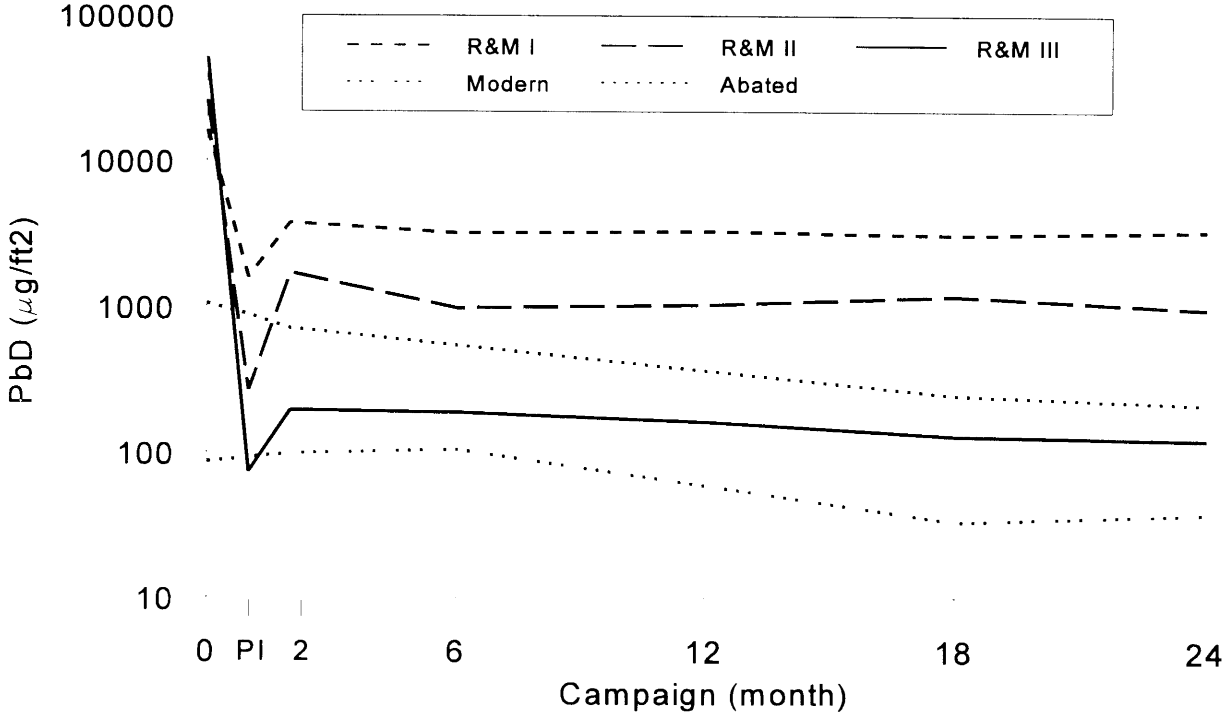
<u>Main Findings Related to Dust Lead Loadings and Concentrations and Dust Loadings</u>

Median dust lead loadings and concentrations based on floor, window sill and window well surfaces are displayed in Figure ES-1 and Table ES-1 to provide a sense of the overall magnitude of house dust lead levels over time within and between groups. Among R&M groups, pre-intervention dust lead loadings tended to be highest in vacant R&M III houses, lowest in occupied R&M I houses, and intermediate in R&M II, which was a mix of vacant and occupied houses.

- All three levels of R&M intervention were associated with statistically significant reductions in house dust lead loadings and total dust loadings that were sustained below pre-intervention levels during two years of follow-up. Dust lead concentrations were significantly reduced following intervention in the middle level (R&M II) and high level (R&M III) intervention houses, but not in the low level intervention houses (R&M I). Further, the three levels of R&M interventions did not reduce lead loadings, lead concentrations, and dust loadings to the same extent.

* Overall median values are summary measures based on combined R&M cyclone dust data across floors, window sills, and window wells within a house, weighted by surface area sampled. (Month O=Baseline;

Figure ES-1: Overall Median Dust Lead Loading (PbD) by Group*



* Overall median values are summary measures based on combined R&M cyclone dust data across floors, window sills, and window wells within a house, weighted by surface area sampled. (Month 0=Baseline; PI=Immediately Post Intervention; Abated=Previously Abated between 5/1988 and 2/1991)

When interpreting Figures ES-1 to ES-4 some caveats should be noted. First, the overall summary measure plotted in Figure ES-1 is not directly comparable to HUD interim clearance standards and EPA clearance standard guidance for lead in house dust, both of which are surface specific (floors: 100 $\mu g/ft^2$; window sills: 500 $\mu g/ft^2$; window wells: 800 $\mu g/ft^2$) and based on wipe samples. The median values in Figures ES-2 to ES-4 are also not directly comparable to clearance standards for lead in house dust due to the sampling method used. Data at immediately post-intervention (PI) and at two-months post-intervention are relevant to the three R&M groups only. The median values presented in Figures ES-1 to ES-4 are not adjusted for season or other covariates or potential effect modifiers.

Table ES-1: Overall Median Dust Lead Loadings ($\mu g/ft^2$), Lead Concentrations ($\mu g/g$) and Dust Loadings (mg/ft^2) by Group for Selected Campaigns *

Measure and Group	Baseline	Post-Intervention	2 Months	12 Months	24 Months
Lead Loading:					
R&M I	16,150	1,580	3,760	3,300	3,320
R&M II	25,930	270	1700	1,020	960
R&M III	51,210	70	200	160	120
Prev. Abated	1,050	n/a	n/a	370	210
Modern Urban	90	n/a	n/a	60	40
Lead Conc.:					
R&M I	18,790	7,990	16,800	16,150	8,700
R&M II	16,830	6,910	10,970	5,600	6,340
R&M III	22,010	2,650	1,530	1,080	890
Prev. Abated	2,430	n/a	n/a	3,010	1,130
Modern Urban	210	n/a	n/a	310	290
Dust Loading:					
R&M I	940	140	260	250	260
R&M II	1,610	40	160	220	200
R&M III	2,510	30	130	140	130
Prev. Abated	290	n/a	n/a	220	190
Modern Urban	400	n/a	n/a	140	140

* Overall median values are summary measures based on combined R&M cyclone dust data across floors, window sills, and window wells within a house, weighted by surface area sampled.

n/a = not applicable

Main Dust Findings (cont.)

- Immediately after intervention and during two-years of follow-up, dust lead loadings, lead concentrations and dust loadings were lowest in R&M III houses, intermediate in R&M II houses, and highest in R&M I houses (Figure ES-1; Table ES-1). For example, at 24 months, overall median lead loading estimates were 27 times higher in R&M I houses than in R&M III houses, and eight times higher in R&M I houses than in R&M II houses. Statistically significant differences were found between R&M groups on the two dust lead measures over time. Differences in lead loadings between R&M groups were primarily due to differences in lead concentrations and secondarily to differences in dust loadings.

- Surface-specific data for lead loadings and concentrations show that the differences between R&M groups after intervention were most pronounced for window wells and window sills as compared to floors (Figures ES-2 - ES-4; Tables ES-2 - ES-3). Moreover, across groups and time, window wells had the highest lead loadings, floors the lowest, and window sills were intermediate.

- Reaccumulation of dust and dust lead loadings in all three R&M groups was the greatest during the first two months after intervention, while there was relatively little reaccumulation between two months and 24 months post-intervention (Figures ES-1-ES-4).

- The modern urban control group had significantly lower dust lead loadings and concentrations across time than the other four groups (Figures ES-1 - ES-4, Tables ES-1 and ES-2). These houses, located in clusters of urban houses built after 1979, were expected to reflect the lowest residential and ambient lead levels in the urban environment. Low dust lead concentrations (overall medians <400 µg/g, equivalent to 0.04 percent) and drip-line soil lead concentrations (geometric means 70 µg/g) support the assumption that these houses were free of lead-based paints. Dust lead levels in the previously abated control houses four years to six years post-abatement were generally similar to those in R&M III houses at the end of the second year of follow-up (Figure ES-1).

- No evidence was found for selection bias when R&M study houses were compared to houses that were considered for study but later rejected, mainly due to lack of timely cooperation with the loan process, family moves and safety concerns.

Figure ES-2: Median Floor Dust Lead Loading by Group

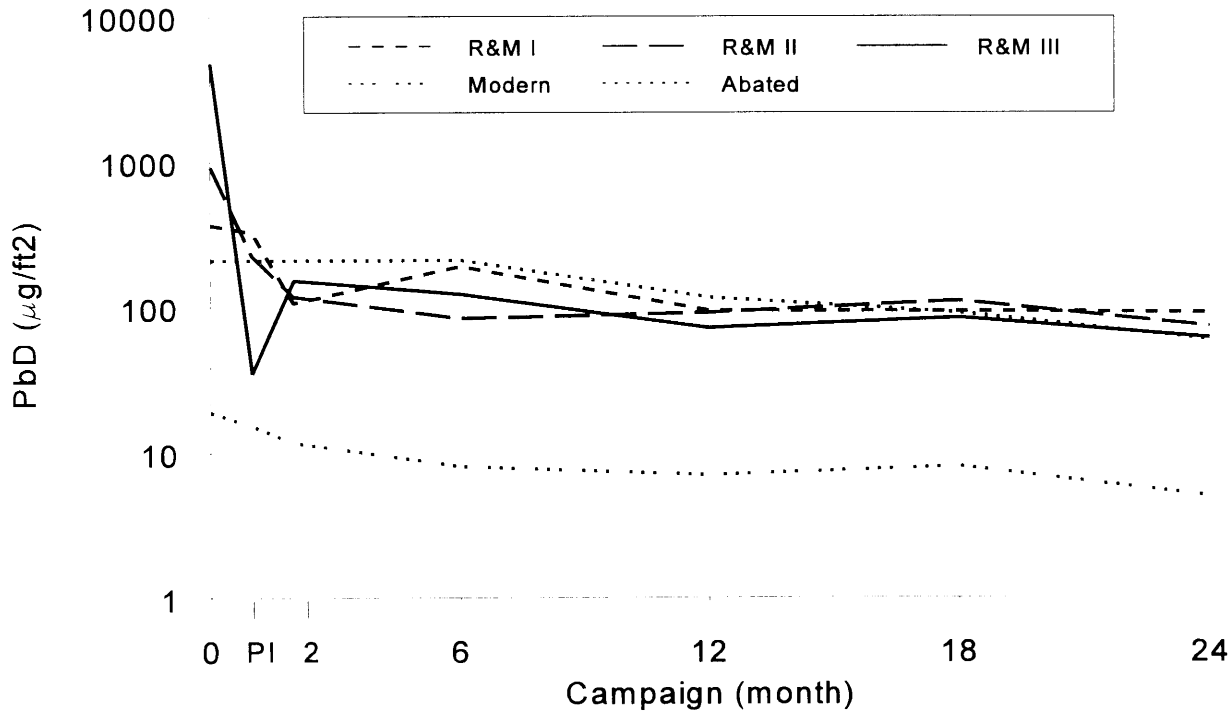


Figure ES-3: Median Window Sill Dust Lead Loading by Group

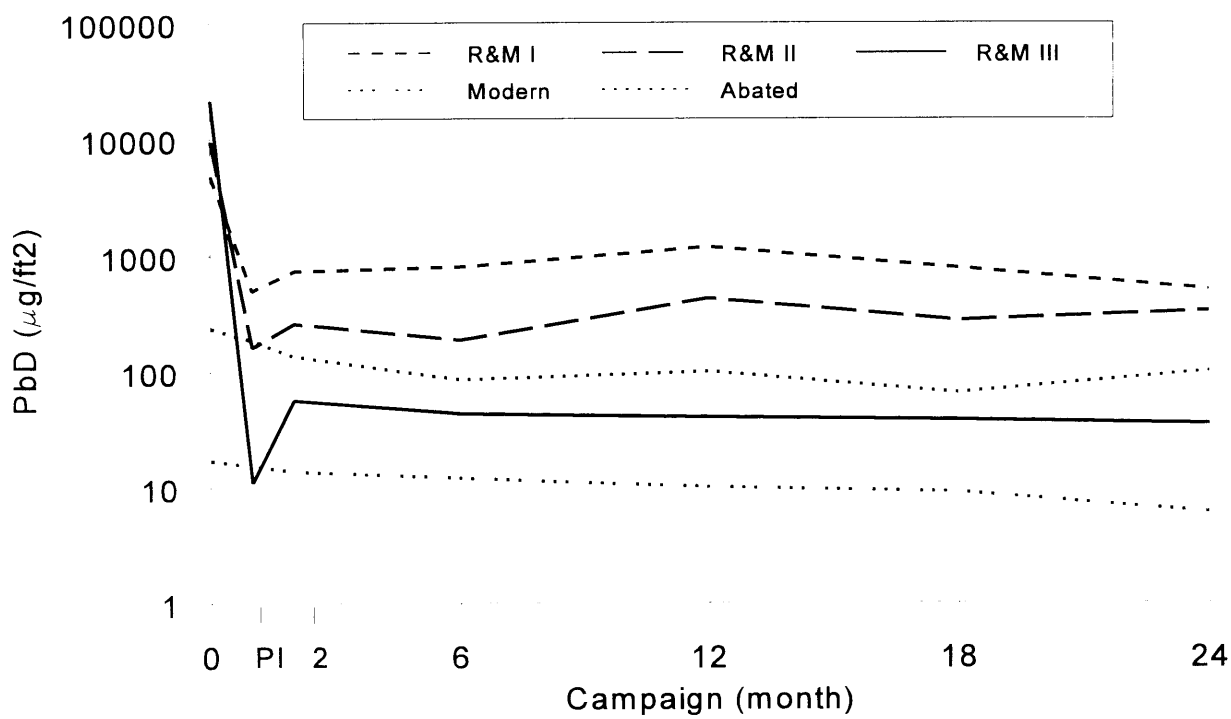
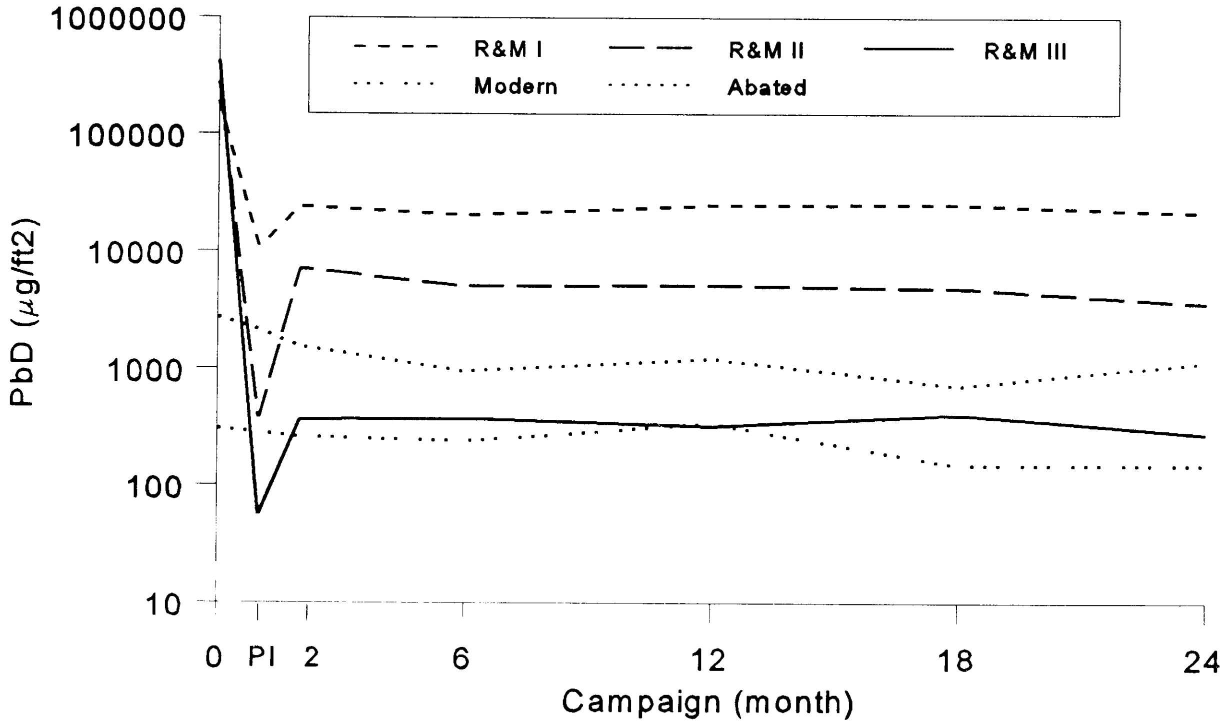


Figure ES-4: Median Window Well Dust Lead Loading by Group



Main Findings Related to Children's Blood Lead Concentrations

- Using all five study groups in the longitudinal data analysis, a statistically significant relationship was found between a composite measure of house dust lead in an entire house (both concentration and loading) and children's blood lead concentration, controlling for age and season.

- Children in the modern urban group had significantly lower blood lead concentrations than children in each of the other four groups (Table 22); their blood lead concentrations were <10 μg/dL, the Center for Disease Control's level of concern (Figure 17).

- Children with baseline blood lead concentrations ≥15 μg/dL in each of the three R&M groups and the previously abated group had statistically significant reductions in blood lead concentration during follow-up, after controlling for age, gender and season (Table 23).

Table ES-2: Median Dust Lead Loadings ($\mu g/ft^2$) by Surface Type and by R&M Group for Selected Campaigns

Surface Type	Group	Pre-Intervention	Post-Intervention	2 Months	12 Months	24 Months
Floor	R&M I	370	330	110	90	90
	R&M II	910	230	120	90	70
	R&M III	4,780	35	150	70	60
Window Sill	R&M I	4,800	500	740	1,180	510
	R&M II	9,560	160	260	420	330
	R&M III	21,670	10	60	40	40
Window Well	R&M I	187,170	10,760	24,250	24,970	21,530
	R&M II	273,980	380	7,150	5,080	3,590
	R&M III	420,970	60	370	330	280

Table ES-3: Median Dust Lead Concentrations ($\mu g/g$) by Surface Type and by R&M Group for Selected Campaigns

Surface Type	Group	Pre-Intervention	Post-Intervention	2 Months	12 Months	24 Months
Floor	R&M I	2,050	1,460	770	750	740
	R&M II	2,850	3,250	1,200	720	700
	R&M III	4,070	1,840	850	560	600
Window Sill	R&M I	16,890	16,620	8,740	10,100	9,940
	R&M II	15,260	8,030	6,600	4,500	3,260
	R&M III	14,860	617	1,020	630	830
Window Well	R&M I	27,960	25,624	32,190	26,840	23,330
	R&M II	22,430	13,390	12,750	7,450	8,970
	R&M III	21,680	2,040	1,560	1,220	1,250

Main Blood Lead Findings (cont).

- Overall, children in the three R&M groups with baseline blood lead concentrations <15 µg/dL had a statistically significant reduction in blood lead concentration over time, when controlling for age, gender and season (*e.g.,* the predicted blood lead concentration at 24 months was on average 20 percent lower than the baseline level). However, no statistically significant differences in predicted blood lead concentration were found between and within individual R&M groups during the two years of follow-up, controlling for age, gender and season (Table 22). Cumulative body lead burden, neighborhood housing characteristics and age at start of study are discussed as factors that may have mediated children's blood lead responses to the R&M interventions and contributed to the differences in blood lead concentrations observed between children in the modern urban group and those in the other four groups.

- Across groups, most children who reached the age of six months during follow-up had blood lead concentrations <10μg/dL, the CDC level of concern, despite increases in blood lead concentration over time (Figure 19). The small number (n=16) of such children precluded further data analysis, however they add to our understanding of the potential role of R&M interventions in the primary prevention of lead poisoning.

It should be emphasized that the R&M interventions under investigation are interim control or partial abatement approaches to reducing lead-based paint hazards. As such, they are not expected to be as long-lasting as lead-based paint abatement work. During the first two years of follow-up, none of the interventions in individual houses failed, that is, all or most of the dust samples showed lead loadings at, or below, pre-intervention levels. Thus, a major study objective with important policy implications remains the documentation of the longevity of the R&M interventions. Toward this end, the study has been extended to five years of follow-up with funding from HUD. Lastly, it is important to recognize that the costs of the interventions in this study may not be generalizable to other settings and time periods.

1.0 INTRODUCTION

This report presents the results of the first two years of follow-up in the Lead-Based Paint Abatement and Repair & Maintenance (R&M) study in Baltimore, conducted by the Kennedy Krieger Research Institute. The study is a longitudinal trial of housing interventions designed to reduce children's exposure to lead in paint and settled dust in their homes (EPA, 1992). Baseline demographic, environmental, and biological data were reported previously for the five groups of houses and residents studied, which included houses designated for R&M intervention Levels I through III, modern urban control houses built after 1979, and previously abated control houses that had received comprehensive abatement between 1988 and 1991 (EPA, 1996a). Findings based on the first year of follow-up were also reported previously (EPA, 1997). This document represents the final EPA report on lead levels in settled house dust and children's blood associated with the three levels of interim control interventions and the comprehensive form of abatement under investigation (Table 1 and Section 4.2). This report includes one additional R&M III household not included in the baseline report.

At baseline, the study population consisted of 108 African-American households (141 children in 108 rowhouses) with low-to-moderate monthly rents or mortgages. R&M households were recruited from lists of Baltimore City properties owned by collaborating property owners. Mean ages of children studied ranged from 25 months to 34 months across the groups. Initial geometric mean blood lead concentrations were 9 µg/dL in the R&M I group, and 13 µg/dL in R&M II, 14 µg/dL in R&M III, 3 µg/dL in the modern urban group, and 12 µg/dL in the previously abated group. Baseline blood lead concentrations in the modern urban group were statistically lower than baseline levels in the other four groups. Further, at baseline children's blood lead concentrations were correlated significantly (r=.28 to .64) with measures of lead in dust from six types of interior house surfaces and exterior entryways.

Houses in all study groups were generally similar in terms of characteristics that might be expected to influence patterns of dust movement into and within a house, including overall size, number of windows, house type and design, condition, distance from the street, and the presence of porches and yards. Statistically significant differences were not found in demographic characteristics and dust lead concentrations between R&M groups at baseline. However, children’s blood lead concentrations and house dust lead loadings at baseline tended to be highest in R&M III houses (vacant at time of dust lead baseline), lowest in R&M I houses (occupied at time of dust lead baseline), and intermediate in R&M II houses (a mix of vacant and occupied houses at time of dust lead baseline). At baseline, overall median lead loadings within an entire house based on floors, window sills and window wells were 16,150 µg/ft^2 in R&M I houses, 25,930 µg/ft^2 in R&M II houses, and 51,210 µg/ft^2 in R&M III houses, compared to 90 µg/ft^2 in the modern urban houses. Similarly derived overall median dust lead concentrations at baseline were nearly two orders of magnitude higher in R&M houses (18,790 µg/g in R&M I; 16,830 µg/g in R&M II; and 22,010 µg/g in R&M III) than in modern urban houses (210 µg/g). Previously abated houses had intermediate overall median dust lead concentrations of 2,430 µg/g and lead loadings of 1,050 µg/ft^2. The baseline campaign in the previously abated houses represents a point two years to four

Table 1: Comparison of Elements of Repair & Maintenance Levels I - III

ELEMENT OF INTERVENTION	R & M LEVEL I	R & M LEVEL II	R & M LEVEL III
TESTING	Test for the presence of lead-based paint (LBP) on interior and exterior surfaces. Use results to develop the R&M Plan.	Test for the presence of lead-based paint (LBP) on interior and exterior surfaces. Use results to develop the R&M Plan.	Test for the presence of lead- based paint (LBP) on interior and exterior surfaces. Use results to develop the R&M Plan.
FLOOR TREATMENTS	Place textured walk-off mat at main entryway.	Seal floors with sealants/paints to make them smoother and easier to clean. Place textured walk-off mat at main entryway. In occupied units, treat floors to extent possible. If floor has LBP, provide floor covering (not sealant).	Make floors smoother and easier to clean using combination of sealants and more durable coverings (e.g., vinyl tile). Place textured walk-off mats at main entryway. If LBP, provide floor covering (not sealant).
TRIM COMPONENT TREATMENTS	Remove loose and peeling LBP on interior surfaces, and on exterior surfaces to limit of budget. Repaint treated components.	Remove loose and peeling LBP on interior surfaces, and on exterior surfaces to limit of budget. Repaint treated components. If not LBP, make interior surfaces smooth and cleanable.	Seal, encapsulate, or enclose LBP on interior and exterior surfaces. If not LBP, make interior surfaces smooth and cleanable.
STAIRWAY TREATMENTS	None	If LBP present, encapsulate treads and risers, at minimum. If not LBP, make smooth and cleanable.	If LBP present, enclose treads and risers using durable materials. If not LBP, make smooth and cleanable.
WINDOW TREATMENTS	Install aluminum cap on window wells. Prepare and repaint all exterior window trim. Repaint interior stool with non-flat paint.	If LBP present, treat in-place to reduce friction. Stabilize paint on exterior trim. Install aluminum caps on wells. Repaint interior sill with non-flat paint. If not LBP, make smooth and cleanable.	If LBP present, replace window and abate exterior window trim by enclosing with aluminum coverings. If not LBP, make smooth and cleanable.
DOOR TREATMENTS	Same as TRIM COMPONENT TREATMENTS.	If LBP, rework interior and exterior doors to reduce friction. Remove peeling LBP paint and stabilize exterior door trim. Repaint treated surfaces. If not LBP, make smooth and cleanable.	If LBP, rework interior and exterior doors to reduce friction or replace. Remove peeling paint. If not LBP, make smooth and cleanable. Enclose LBP on exterior door trim with aluminum coverings.

Table 1: Comparison of Elements of Repair and Maintenance Levels I - III
(Continued)

ELEMENT OF INTERVENTION	R & M LEVEL I	R & M LEVEL II	R & M LEVEL III
WALL TREATMENTS	Same as TRIM COMPONENT TREATMENTS.	If LBP and < 25% of component is damaged, repair damaged area and seal component, at a minimum. If LBP and >25% of component is damaged, repair damaged area and treat by use of flexible encapsulant or rigid enclosure.	If LBP and < 25% of component is damaged, repair damaged area and encapsulate, at a minimum. If LBP and >25% of component is damaged, then treat by use of flexible encapsulant or rigid enclosure.
FINAL CLEAN-UP	HEPA vacuum all horizontal surfaces and window components (ceilings excluded). Then wet clean horizontal surfaces.	HEPA vacuum all surfaces excluding ceilings. Then wet clean horizontal surfaces.	HEPA vacuum all surfaces excluding ceilings. Then wet clean horizontal surfaces.
CLEANING KITS	Provide cleaning kits to occupants for use after R&M work is completed.	Provide cleaning kits to occupants for use after R&M work is completed.	Provide cleaning kits to occupants for use after R&M work is completed.
EDUCATION	Provide educational materials about lead poisoning to occupants.	Provide educational materials about lead poisoning to occupants.	Provide educational materials about lead poisoning to occupants.
COST*	Capped at $1,650	Capped at $3,500	Capped at $6,000 to $7,000 (This range is due to program criteria and pre-existing program agreements.)

* The R&M interventions were financed by the Maryland Department of Housing and Community Development through a special loan program open to low-income owner-occupants and private property owners who rent their properties to low-income tenants. The costs of the interventions in this project may not be generalizable to other settings and time periods due to differences in labor costs, material costs, and overhead rates.

years post-abatement. Further, it is important to note that the lead loading estimates in this report are based on R&M cyclone samples; as such they are not directly comparable to HUD (1995) interim clearance standards and EPA (1995a) clearance standard guidance for lead in house dust.

1.1 Purpose of the R&M Study

Past studies have documented the short-term (2 months to 6 months) and longer-term (12 months or longer) effectiveness of comprehensive approaches to residential lead paint abatement intended to attain long-term control of lead-based paint hazards (Farfel, 1991 and 1994a). In recent years, there has been growing interest in the concept of interim measures to temporarily control the extensive problem of lead-based paint hazards in housing in a cost-effective manner. Title X of the Housing and Community Development Act of 1992 (P.L. 102-550) defined interim controls as "a set of measures designed to reduce temporarily human exposure or likely exposure to lead-based paint hazards, including specialized cleaning, repairs, maintenance, painting, temporary containment, ongoing monitoring of lead-based paint hazards or potential hazards and the establishment of management and resident education programs." More recently, the June 1995 HUD *Guidelines for the Evaluation and Control of Lead-Based Paint Hazards in Housing* operationalized the concept by compiling information on interim control practices (HUD, 1995). Many believe these measures will benefit large numbers of current and future occupants of housing with lead-based paint hazards. However, little is known about the short- and long-term effectiveness of this approach (EPA, 1995c).

The R&M study is designed to document the short- and long-term effectiveness of a range of housing interventions, including interim control measures, designed to reduce children's exposure to lead in residential paint and settled house dust. This research is important because house dust and residential paints containing lead have been identified as major sources of exposure in U.S. children (ATSDR, 1988; CDC, 1991 and 1997a; Clark, 1991; Chislom, 1986; Charney, 1983; Lanphear, 1994) primarily via the hand-to-mouth route of ingestion (ATSDR, 1988; Bornschein, 1986; Charney, 1982; Roels, 1980; Sayre, 1974). Families with children under seven years of age occupy approximately 10 million of the 64 million privately owned and occupied U.S. housing units that are estimated to contain some lead-based paint (HUD, 1990; EPA, 1995b). Children living in the nearly 4 million houses with deteriorating paint and elevated dust lead levels are at highest risk of exposure (HUD, 1990). Given the extent of the problem and its adverse health and social consequences, the acute shortage of affordable housing free of lead-based paint in many urban areas, and the high costs of complete lead-based paint abatement, the preventive R&M approach may provide a means of reducing exposure for future generations of U.S. children who will continue to occupy housing that contains lead-based paint. This study represents the first systematic examination of the R&M approach.

The goal of the study is to contribute to the existing scientific bases needed to develop a standard of care for lead-painted houses through the analysis of environmental and biological data from a longitudinal intervention study. Specific study aims are listed below in Section 1.2.

1.2 Specific Research Aims and Report Objectives

The specific research aims and objectives of this report are to:

- Assess the effectiveness and longevity of the three levels of R&M interventions by investigating the short- and longer-term changes in the lead concentration and lead loading of settled house dust.

  Towards this end, this report describes lead loadings and concentrations in settled house dust for the three levels of R&M intervention at baseline and across the six data collection campaigns conducted during the first two years of follow-up, *i.e.*, immediate post-intervention, and two months, six months, 12 months, 18 months, and 24 months post-intervention. This report also presents the findings of the longitudinal data analysis in which statistical models were fit to the dust lead data to assess dust lead over time within and between R&M groups, after controlling for covariates including season.

- Investigate lead loadings and concentrations in settled dust between baseline and the 24-month campaign for a control group of modern urban houses built after 1979 and a group of houses that received comprehensive abatement between May 1989 and February 1991.

  This report describes lead loadings and concentrations in settled house dust for these two control groups at baseline and after six months, 12 months, 18 months, and 24 months of follow-up. Also presented are the statistical models for longitudinal data analysis fit to the dust lead data from all five study groups to assess dust lead levels over time within and between groups, after controlling for covariates including season.

- Assess children's blood lead concentrations associated with the three levels of R&M interventions and the two control groups.

  Towards this end, this report describes blood lead concentrations in children by group at baseline and across the multiple data collection campaigns conducted during the first two years of follow-up. The results of the fitting of statistical models for longitudinal data analysis to the blood lead data are also presented. These models compare blood lead levels over time within and between groups, after controlling for covariates including age.

  It is important to note that despite the ages of the children at baseline and their lead-exposure at baseline as determined by blood lead concentration (mentioned in above in Section 1.0), this study can determine in several ways the degree to which the R&M interventions are effective in preventing lead exposure as measured by children’s blood lead concentrations. First, it can show whether their blood lead concentrations reach levels that trigger medical management ($\geq$15-20 μg/dL according to the CDC guidelines) during the post-intervention period of follow-up. Second, it can show whether R&M interventions are associated with acute increases in children’s blood lead concentrations during the immediate post-intervention phase; this is important because past studies have documented acute increases in children’s blood lead following improper lead-paint abatement work. Third, the study design included the enrollment of children who reached the age of six months during the follow-up phase to increase our understanding of the role of R&M interventions in the primary prevention of lead poisoning.

- Assess the nature of the relationship between blood lead and dust lead. For this, statistical models for longitudinal data analysis were fit to the blood lead and dust lead data from all five study groups.

- Report on compliance with laboratory and data quality objectives (see Section 3.0: Quality Assurance).

- Evaluate and compare methodologies for the collection and analysis of lead in residential dusts, including wipe and cyclone methods. This objective was addressed in past reports and articles (Farfel, 1994b, 1994c, 1994d).

1.3 Peer Review

The three independent external reviewers recommended publishing the report after minor revisions. A number of their comments related to the importance of highlighting surface-specific patterns of dust lead loadings between and within R&M groups in addition to patterns based on overall summary measures across multiple surface types. Several other comments related to the use and interpretation of factor analysis (*e.g.*, derivation of factors and the meaning of factor scores and factor patterns). One reviewer requested that additional information be added to the Executive Summary to make the results more accessible to the reader.

To address these and other comments, the Executive Summary was expanded to include a brief description of the three levels of R&M interventions and tables and figures summarizing overall and surface-specific dust lead loadings, lead concentrations and dust loadings over time by group. These tables and figures enable one to assess the degree to which the three levels of R&M interventions affected dust lead levels. Further, it should be noted that these overall median measures were not used in the longitudinal data analysis. Also, noteworthy is the fact that floors contributed the most to the overall median dust lead loadings due to the large floor surface area sampled for each interior floor composite sample (up to 6 square feet) relative to the area sampled for each window sill and window well composite sample. This report also includes a discussion of the observed surface-specific patterns of dust lead loadings. To address comments regarding the use and interpretation of factor analysis, additional text was added to Section 6.3 (Statistical Analysis).

One reviewer asked how duration of exposure at a given level of R&M was accounted for in the longitudinal analysis of the relationship between dust lead and blood lead. Duration of exposure was accounted for in the longitudinal data analysis in several ways. First, children were included in model up to the time of their move from the study house. Secondly, only children with at least two months of contact with the house were included in the analysis of the relationship between blood lead and dust lead at baseline. Thirdly, the addition of a variable that reflected the duration of the child's residency in the study house post-intervention did not add significantly to the exposure model (see Section 6.3) in the presence of the dust factors, age and season.

A reviewer pointed out that at baseline R&M I houses were occupied, R&M III were vacant and that R&M II houses were a mix of vacant and occupied houses and asked whether baseline occupancy status was addressed in the data analysis. In analyzing the R&M data, we included a variable for occupancy status at baseline (occupied/vacant) and found that it did not make a statistically significant contribution to the models. Further, the reviewer's point would be of particular importance if this were a short-term study of changes in dust lead loadings and concentrations immediately following R&M intervention. However, in this longitudinal study, the data were analyzed in terms of dust lead loadings and concentrations during the two years of follow-up, both within and between groups, and not in terms of absolute change in dust lead immediately following intervention.

One reviewer correctly pointed out that the estimates of dust lead loadings based on dust collected using the R&M study cyclone device are not directly comparable to lead loadings based on the HUD wipe method, and therefore, comparisons to HUD clearance standards are not meaningful without a clarifying statement. Caveats were added to the Executive Summary and the body of the report to address this point. On a related point, another reviewer noted that two recent studies suggest that the current HUD clearance standards and EPA guidance levels for lead in dust may be too high to protect children from blood lead concentrations greater than or equal to 10 μg/dL. These two studies are noted and referenced in this report (Clark, 1995; Lanphear, 1996).

Other changes to the report based on reviewers' comments include the following: a list of specific research aims was added to section 1.2; examples of the letters informing residents of dust and blood test results were added to Appendix A; an expanded discussion of differences in window treatments was added to the Discussion section; and Table 1 was revised to clarify the fact that R&M III, unlike R&M II, included the use of more durable floor coverings (e.g., vinyl tile) in addition to floor sealants. In the infrequent event that a floor was found to be coated with lead-based paint in R&M II and R&M III houses, the floor was covered with a barrier material rather than with a sealant or paint.

It should be noted that EPA has established a public record for peer review. The record is available in the TSCA Nonconfidential Information Center located in Room NE-B607, Northeast Mall, 401 M Street, SW, Washington, D.C. The Center is open from 12:00 noon to 4:00 pm, Monday through Friday, except for legal holidays.

2.0 SUMMARY AND DISCUSSION OF FINDINGS

The following sections summarize and discuss the main findings of the study, including those based on the fitting of statistical models for longitudinal data analysis (Section 6.3) to the dust lead and blood lead data. These sections refer to data tables and figures that appear in the Executive Summary and the Results Section (7.0). The longitudinal models were used to investigate lead levels in house dust and in children's blood across time within study groups as well as to make comparisons between groups during the two years of follow-up, accounting for age, season, and other potential covariates. These models also address statistical issues associated with having multiple measurements per house and repeated measures over time.

In interpreting the findings from this study, it is important to bear in mind that the dust lead loading estimates based on the R&M cyclone sampler are not directly comparable to HUD's (1995) interim clearance standards and EPA's (1995a) clearance standard guidance for lead in house dust which are based on wipe dust samples.

During the two years of follow-up, this study met objectives related to enrollment, laboratory performance, data quality, and data completeness (Section 3.0). The latter is attributable to the study families' willingness to cooperate with the blood lead testing and the environmental sampling components of the study. During the course of the study, 96.5% of the planned home visits for environmental sampling were accomplished. This, in turn, is a reflection of the good rapport established between study staff and participating households. During the first two years of follow-up, 38 (35 percent) of the 108 original families moved from study houses; four houses experienced two family moves. In 35 of the 42 family moves (83%), the house was subsequently reoccupied and the new family was enrolled in the study. This assured that, at a minimum, the house remained in the study. Most of the new families also had eligible children who were enrolled in the blood lead testing component of the study.

Nature of the Intervention

The study intervention consisted of a combination of R&M work and the provision of information to families on a periodic basis. Cost caps for R&M Level I-III work imposed by the state agency funding the interventions necessitated prioritization of the R&M work to be done in any given study house. Additional repairs done by the property owner were taken into account and resulted in the reclassification of two R&M II houses to R&M III at baseline and three R&M I houses to R&M III during follow-up. Due to concerns about the potential for reaccumulation of lead in dust following intervention in study houses receiving these previously untested R&M interventions, all study families were informed by letter of the results of the dust lead and blood lead tests from each campaign in which they participated (Appendix A). In the absence of a standard for lead in house dust, dust test results were provided on a qualitative basis with recommendations for housekeeping priorities to address areas with dust lead loadings higher than what we would expect to find in a house free of lead-based paint or in a completely renovated house. As required by Maryland law, all blood lead results were reported to the Maryland Childhood Blood Lead Registry which in turn reported the results to the Baltimore City Health Department for follow-up and case management.

Thus, this study add to, but did not replace usual medical care or case management.

The dual nature of the intervention is consistent with HUD (1990) guidelines which recognize the need for ongoing inspection (and maintenance) of houses that receive interim control interventions and with Title X legislation which includes ongoing monitoring of lead-based paint hazards and resident education programs as a part of its definition of interim controls. On the other hand, the nature of the intervention limits the degree to which study findings can be generalized to houses that will receive similar R&M interventions, but no periodic monitoring of dust lead levels and/or feedback of results to families. Furthermore, as mentioned previously the costs of the R&M interventions in this study may not be generalizable to other settings and time periods.

Dust Lead In R&M Houses

All three levels of R&M intervention under investigation (Table 1 and Section 4.2) were associated with statistically significant reductions in both interior dust lead loadings and dust loadings that were sustained below pre-intervention levels during the two years of follow-up. However, the three levels of R&M interventions did not reduce lead loadings, lead concentrations, and dust loadings to the same extent. Moreover, none of the interventions in individual houses failed, *i.e.*, all or most of the interior dust lead loading measurements in individual R&M houses were at or below pre-intervention levels during the two years of follow-up. At sporadic sites in individual study houses (particularly in R&M I houses) dust lead loadings did reaccumulate to levels close to pre-intervention levels. If intervention failures had been detected during follow-up, contingency funds would have been used to perform additional remediation work.

Dust lead concentrations were found to be statistically significantly reduced following intervention in R&M III houses and R&M II houses (except for immediately after intervention in R&M II) but not in R&M I houses (Section 7.3). During follow-up, lead concentrations were statistically significantly lower in R&M III houses than in R&M I and R&M II houses at all post-intervention data collection campaigns. Significant differences in dust lead concentrations between R&M groups were anticipated based on differences between the three levels of intervention. By design, R&M III interventions, and to a lesser extent R&M II interventions, directly addressed lead-based paint, a source of high lead concentrations in house dust. For example, R&M III interventions typically involved the replacement of lead-painted windows and the use of durable aluminum coverings to enclose lead paint on exterior components of windows and doorways. In R&M II interventions, window friction surfaces were treated to reduce the abrasion of lead paint, but windows generally were not replaced. In contrast, R&M I interventions directly addressed paint sources only to the extent that deteriorating paint on interior and exterior surfaces was stabilized and window wells were capped with aluminum coverings. Sustained reductions in lead concentrations in R&M II and R&M III houses (Tables ES-1 and ES-3), and less frequent observations of paint chips on sampled window surfaces during follow-up, indicate that these interventions contributed to the control of paint as a source of high lead concentrations in house dust for a two-year period. Moreover, surface-specific differences in dust lead loadings and concentrations across R&M groups during follow-up were greatest for window wells and window sills as compared to floors (Figures ES-2 to ES-4; Tables ES-2 and ES-3).

Reaccumulation of dust and dust lead loadings in all three R&M groups was the greatest during the first two months after intervention, while there was relatively little reaccumulation between two months and 24 months post-intervention (Figure ES-1 and Figure 23, see section 6.3 for an explanation of factor scores in Figure 23). This early reaccumulation was most evident in R&M II and R&M III houses and may be due in part to the possible importation of dust and lead into the house during move-in by study families. Half of the R&M II houses, all of the R&M III houses, and none of the R&M I houses were vacant at the time of intervention. Vacancy is also believed to account for the finding that baseline dust lead loadings were highest in R&M III houses, lowest in R&M I houses and intermediate in R&M II houses (Table ES-1).

As expected, the dust lead loadings, lead concentrations, and dust loadings during the post-intervention period of follow-up were related to the intensity of the intervention. Environmental samples collected at all data collection campaigns following intervention consistently showed dust lead loadings, lead concentrations, and dust loadings to be lowest in R&M III houses, intermediate in R&M II houses, and highest in R&M I houses (Tables ES-1 to ES-3; Figures 1-12). Statistically significant differences were generally found between R&M groups on these three dust measures throughout the two-year period of follow-up. Overall median dust lead levels based on floors, window sills, and window wells in an entire house indicated that the relative differences in exposure between groups were large (Figure ES-1). For example, at 24 months, overall median lead loading estimates were 27 times higher in R&M I houses than in R&M III houses, and eight times higher in R&M I houses than in R&M II houses.

As noted above, surface-specific data for lead loadings and concentrations show that the differences between R&M groups after intervention were most pronounced for window wells and window sills as compared to floors (Figures ES-2 - ES-4; Tables ES-2 - ES-3). Appendix B provides descriptive statistics for each surface type by group at the 24-month campaign. In R&M I houses, the 24-month geometric mean dust lead loading for floors in rooms with windows was 58 µg/ft^2, for window sills it was 460 µg/ft^2, and for window wells it was 9,828 µg/ft^2. In R&M II houses, the 24-month geometric mean dust lead loading for floors in rooms with windows was 59 µg/ft^2, for window sills it was 195 µg/ft^2, and for window wells it was 2,122 µg/ft^2. Finally, in R&M III houses, the 24-month geometric mean dust lead loading for floors in rooms with windows was 53 µg/ft^2, for window sills it was 26 µg/ft^2, and for window wells it was 164 µg/ft^2.[a] Differences in lead loadings between groups are attributable mainly to differences in lead concentrations between groups and secondarily to differences in dust loadings (Table ES-1; Figure 23).

Dust samples were also collected separately in rooms without windows. Approximately half of the study houses had such rooms. At baseline, floors in rooms without windows tended to have lower lead loadings, lead concentrations and dust loadings than floors in rooms with windows. This

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[a] It should be noted that the cyclone device used to collect dust in this study has been shown to produce higher estimates of dust lead loadings compared to wipes across a range of surface types and conditions. However, the cyclone device tends to yield lower estimates of dust lead loadings than wipes on smooth surfaces with lead loadings less than approximately 100 µg/ft^2 (Farfel, 1994c).

finding is consistent with the fact that windows are a source lead in paint and dust. After intervention, dust lead loadings, lead concentrations and dust loadings for floors in rooms with and without windows were comparable (Appendix B).

The provision of smooth and easily cleanable surfaces has been shown to be an important element of effective residential lead paint abatement (Farfel, 1991 and 1994a). In this study, surface conditions would have influenced the effectiveness of the post-R&M cleanup by contractors and subsequent housekeeping by study families. The patterns observed in dust loadings and dust lead loadings and concentrations between R&M groups also may be related to the degree to which the household surfaces were made smooth and easily cleanable. For example, in R&M III houses, floors were covered or sealed to make them smooth and easily cleanable. Floors in R&M II houses were sealed, while floors in R&M I houses were neither sealed nor covered. It should be noted that for the subset of R&M II houses that were occupied at the time of intervention, family members were out of the house while work was in progress, and the floors were treated to the extent feasible, given the presence of furnishings and the drying times of the floor sealants and the precautions needed to protect families' furnishings and personal belongings. Further, in all three R&M groups the window wells were covered in some manner to make them smooth and more easily cleanable. Based on field observations, window well surfaces in all three groups of intervention houses were noted to be smoother and less deteriorated during follow-up as compared to the pre-intervention baseline.

Dust Lead In Control Houses

The modern urban and previously abated control houses were characterized by a relative stability of dust lead concentrations, and by downward but nonstatistically significant trends in lead loadings and dust loadings across time (Figures ES-1 to ES-4; Figures 24; Table ES-1). These trends may be related, in part, to families becoming more aware of the importance of lead dust control as a result of study participation and to the fact that dust was repeatedly removed from household surfaces by the sampling process.

The modern urban control houses are rowhouses located in clusters of houses built after 1979 and presumably free of lead-based paint because of the year of construction (CPSC, 1977). It is expected that this type of housing reflects the lowest residential and ambient lead levels in the urban environment. The paint in the modern urban control houses was not tested to determine directly if the paint contains lead additives. However, the consistently low overall interior dust lead concentrations (geometric mean 400 µg/g (ppm), equivalent to 0.04%) and low soil lead concentrations (geometric mean 70 µg/g) support the assumption that these houses are free of lead-based paints. This group of houses had significantly lower dust lead loadings and lead concentrations compared to each of the other study groups at baseline and throughout the two years of follow-up. Moreover, this group was the only group in which all of the children's blood lead levels were less than the CDC's blood lead level of concern. At 24 months, the overall median lead loading in modern urban houses was three times lower than in R&M III houses. The geometric mean dust lead loading for floors in these houses was 5 µg/ft^2, for window sills it was 6 µg/ft^2, and for window wells it was 154 µg/ft^2, compared to previously abated houses where the geometric mean dust lead loading for floors was 48 µg/ft^2, for window sills it was 35 µg/ft^2, and for window wells it was 938 µg/ft^2

(Appendix B: Table B-2).

The previously abated control houses had lead loadings over time that tended to be intermediate to levels found in R&M II and R&M III houses (Figure ES-1). These findings may be related to differences in time since intervention between R&M groups and this control group. For example, the 24-month campaign occurred four years to six years post-abatement in the previously abated control houses. Further, average dust lead concentrations in R&M III houses were not significantly different from those in previously abated houses during follow-up. This finding is consistent with the fact that none of these interventions involved the complete removal of all lead-based paint from a home. As was illustrated by the case in which a child's blood lead concentration rose to 53 µg/dL during follow-up and chelation therapy was provided, the previously abated control houses were not fully abated of lead paint. In these houses, some interior (in this case basement) surfaces that had not been treated due to resource limitations, and some painted exterior surfaces that had been stabilized as part of the original abatement were found to be deteriorated. These problems, combined with deteriorating exterior paint identified on neighboring houses, were likely sources of this child's exposure. This case points to the need for ongoing inspection and maintenance of houses, particularly those houses that receive less intensive interim control interventions.

It should be emphasized that although the effectiveness of the three levels of R&M interventions being investigated has been shown for two years, they are classified as interim control or partial abatement approaches to reducing lead-based paint hazards in housing. As such, they are not expected to be as long-lasting as comprehensive abatement. For this reason, documentation of the longevity of the R&M interventions remains a major study objective during the extended study. Nevertheless, two years is an important time span because children's blood lead concentrations tend to peak at about two years of age (CDC, 1991).

Lead In Drip-Line Soil And Tap Water

Soil and water samples were tested at baseline, six months and 18 months in order to take these sources into account in the analysis of the longitudinal dust lead and blood lead data. Soil lead data were limited due to the absence of drip-line soil at most study houses, except for at modern urban houses. Soil lead concentrations in 10 of the 16 modern urban houses with drip-line soil were consistently low across time (geometric mean <70 µg/g, range of individual values 6 to 747 µg/g, Table 16). These low soil lead concentrations are consistent with the possible use of replacement sod or soil at these houses at the time of construction. Geometric mean soil lead concentrations in the small numbers of houses in the four other study groups with drip-line soil were higher (geometric means 529 µg/g to 2,192 µg/g). Based on limited data, no change was found in soil lead concentrations immediately following intervention for R&M I and R&M II houses. The data were insufficient to assess the change in soil lead for R&M III houses.

Tap water was found to have low concentrations of lead. Geometric mean water lead concentration across groups was 7 µg/L (ppb) across time, and only a small number of readings exceeded the EPA drinking water standard of 15 µg/L (Table 17). The combination of low water lead concentrations and the absence of a significant correlation between children's blood lead concentrations and water lead concentrations indicates that water was not likely to have been an important source of lead exposure in study children. Beyond this, no major conclusions were drawn with regard to these sources, due to the limited generalizability of these water and soil data.

Blood Lead

The most recent estimate is that 930,000 U.S. children have blood lead elevations defined by the U.S. CDC as blood lead concentrations ≥10 µg/dL (CDC, 1997b). The majority of these children have lead concentrations in the range of 10-20 µg/dL. Little is known, however, about blood lead changes associated with lead paint hazard reduction interventions in the homes of children with low-to-moderate blood lead concentrations (EPA, 1995c; Swindell, 1994). In this study, the unadjusted geometric mean blood lead concentrations (PbB) at baseline were 9 µg/dL for R&M I children, 13 µg/dL for R&M II children, and 14 µg/dL for R&M III children, 12 µg/dL for children in the previously abated houses, and 3 µg/dL for children in the modern urban houses.[b] For children in all of the R&M III houses and half of the R&M II houses which were vacant at the time of intervention, the baseline value is the blood lead concentration at, or close to, the time the child moved into the house post-intervention.

One of the longitudinal data analysis models used in the study allowed for comparisons of blood lead concentrations within and between groups, and for control of age, season and other potential covariates. This comparison model was fit separately for children with baseline blood lead concentrations <15µg/dL or ≥15µg/dL. According to CDC guidelines, children with blood lead concentrations ≥20µg/dL and children with persistent blood lead concentrations of 15-19 µg/dL should be referred for clinical evaluation, environmental investigation and remediation, and case management (CDC, 1997a; see Appendix C for more detailed guidelines information).

For children with blood lead concentrations <15 µg/dL at the initial campaign, R&M I children tended to have lower blood lead concentrations at each campaign, including baseline, compared to R&M II and R&M III children. Based on longitudinal data analysis, predicted blood lead concentrations in children in the three R&M groups with initial blood lead concentrations <15 µg/dL were statistically significantly reduced over time, when controlling for age, gender and season (Figure 25a, Appendix F). (Predicted blood lead concentrations are determined from the coefficients from the "best-fitting" statistical model). However, for these children no statistically significant differences in predicted blood lead concentration were found between and within individual R&M

[b] The geometric mean blood lead concentration (PbB) in children in the modern urban group was similar to the geometric mean of 2.7 µg/dL reported for U.S. children aged 12 months to 60 months and lower than that estimated for all U.S. non-Hispanic black children in this age range (4.3 µg/dL, NHANES III Phase 2, Oct. 1991 to Sept. 1994) (CDC, 1997b). The unadjusted geometric mean PbB in each of the other four study groups was similar to, or higher than, the estimated geometric mean PbB value of 9.7 µg/dL in U.S. non-Hispanic black children for low-income families living in central cities (populations ≥1 million, NHANES III Phase 1, 1988-1991) (Brody, 1994).

groups at any follow-up campaign during the two years of follow-up, controlling for age, gender and season (Table 22). At the end of the second year of follow-up, the predicted blood lead concentration was on average 80 percent of the baseline level across the three R&M groups for children with baseline blood lead concentrations <15µg/dL (p-value=.02). At 24 months, the average predicted blood lead concentrations were 6.4 µg/dL for R&M I children, 9.2 µg/dL for R&M II children, 8.7 µg/dL for R&M III children, and 9.9 µg/dL for children in previously abated houses (Table 22). Children in the modern urban control group had statistically significantly lower blood lead concentrations than children in the other four groups. Their predicted blood lead concentrations were 3-4 µg/dL across campaigns, after controlling for covariates. The blood lead concentrations of children in the modern urban group were all less than or equal to the CDC's blood lead level of concern (10 µg/dL) across time (Figure 17).

As anticipated, nearly all children with baseline blood lead concentrations ≥20 µg/dL were in the R&M II and R&M III groups because the policy of one of the main collaborating housing organizations was to rent its improved properties to families with lead-poisoned children (Figures 14-16). Only one child in the R&M I group had a baseline blood lead concentrations ≥20µg/dL. Children across all groups with initial blood lead concentration ≥15 µg/dL had a statistically significant reduction in blood lead concentration (in most cases to levels <15-20 µg/dL) during follow-up, when controlling for age, season, and group, and random house effects (Table 23). The decline in blood lead concentration across groups was greatest between baseline and 12 months. By 24 months, the predicted average blood lead concentrations for children with baseline blood lead concentrations ≥15 µg/dL had dropped from a range of 17.9 μg/dL to 21.7 μg/dL across R&M groups at baseline to a range of 10.3 μg/dL to 14.5 μg/dL (Table 23).

The absence of a statistically significant increase in blood lead concentration at two months post-intervention is noteworthy because past studies have attributed short-term rises in children's blood lead concentrations to improper abatement practices (Rey-Alvarez, 1987; Farfel, 1990; Amitai, 1991; EPA, 1995c). Precautions taken in R&M houses included having children out of the house while R&M work was in progress and the use of work practices to minimize, contain, and remove lead-contaminated dust. Further, one could hypothesize that, accounting for age, the R&M interventions may have prevented increases in blood lead concentrations that study children might have experienced otherwise in the absence of the R&M interventions. For ethical reasons, the study design did not include a non-intervention control group to test this hypothesis.

<u>Children Who Reached the Age of Six Months During Follow-up</u>

Sixteen children who reached the age of six months during the follow-up phase of the study were analyzed separately to assess the potential role of R&M and control houses in the primary prevention of lead poisoning. Across all groups, blood lead concentrations of these children were generally less than or equal to the CDC level of concern (10 μg/dL) at baseline and they remained 10 μg/dL for most children despite increases over time (Figure 19). Children between the ages of six months and 18 months tend to experience the steepest rise in blood lead concentration among preschool children. Moreover, it is notable that the blood lead concentrations of children who reached the age of six months during follow-up in the modern urban control houses remained 5 μg/dL over time. The small numbers of such children precluded further statistical analysis by group. Also with regard to primary prevention, this study found that all study children in the modern urban control houses had blood lead concentrations equal to, or below, the CDC's level of concern (10 μg/dL).

Relationship Between Blood Lead And Dust Lead

Across the various data collection campaigns, statistically significant correlations ranging from r=.20 to .61 were found between children's blood lead concentrations and dust lead loadings and concentrations (both on the log scale) for various surface types (Table 21). These correlations are consistent with those reported in the literature (Lanphear, 1995; Bornschein, 1986). A statistical model was used to assess the relationship between blood lead concentration and dust lead loadings and concentrations, controlling for covariates.

Using data from all five study groups in the longitudinal data analysis, blood lead concentration was found to be significantly related to a linear combination of floor, window sill, and window well dust lead loadings and to a similar composite measure of dust lead concentrations, after controlling for age, season, campaign and the inclusion of random effects for houses. When floor, window sill, and window well dust lead levels were entered separately into the models, floors were found to be a stronger predictor of children's blood lead concentrations than window sills or window wells, after controlling for age, season, campaign and the inclusion of random effects for houses. These findings are consistent with other studies, including the recent cross-sectional study in Rochester (Lanphear, 1994 and 1995) which found a statistically significant relationship between children's blood lead concentrations and lead in settled dust in their homes.[c] Gender was not significantly related to blood lead concentration, and hand-to-mouth activity was not found to be a consistently significant contributor to the model in this study. The latter may be attributed to the more-or-less truncated blood lead concentration distribution and the aging of study children, or to variations in parental reporting of this behavior.

On the other hand, a statistically significant relationship was not found between dust lead loadings and concentrations and blood lead when the statistical model was fitted to blood lead concentration data from just the three R&M groups (Appendix F). This was likely due to the narrower range of post-intervention dust lead loadings and concentrations, compared with pre-intervention dust lead loadings and concentrations, exacerbated by the absence of the low-lead modern urban houses and children living in these types of houses from the analysis.

Seasonal change in children's blood lead concentration was estimated to be +1.2 µg/dL in summer relative to the other seasons, controlling for age, campaign and dust lead loading and concentration. Other studies reported seasonal trends in children's blood lead concentrations for

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[c] Further, two recent studies suggest that current HUD clearance standards and EPA guidance levels for lead in dust may be too high to protect children from blood lead concentrations greater than or equal to 10 μg/dL (Clark, 1995; Lanphear, 1996).

different years and populations that varied in the estimated magnitude of the seasonal difference (EPA, 1995d and 1996b).

Considerations In The Interpretation Of Blood Lead Findings

Multiple factors can theoretically mediate a child's blood lead concentration response to an intervention. These factors may include cumulative body lead burden, age, degree of hand-to-mouth activity, ambient lead levels, and neighborhood housing characteristics.

Reported housing history data, combined with the baseline blood lead concentration data, suggest that children in the modern urban houses had lower body lead burdens at the time of enrollment than did children in the other four study groups. Most children in the modern urban group had lived in the same low-lead house since birth, and all of them had baseline blood lead concentrations less than or equal to the CDC's blood level of concern (10 µg/dL). By contrast, it is likely that the children in the R&M and previously abated houses had spent most or all of their lives prior to enrollment in low-income rental housing (based on reported housing histories) and thus were at risk of high exposure to lead in dust and paint due to poor housing conditions. On average, baseline blood lead concentrations in these four groups of children were three to four times higher than those of children in the modern urban group. Body lead burdens could have mediated children's blood lead concentration responses to the R&M interventions because blood lead reflects a mixture of recent exposure and lead that the body has stored.

Most (70 percent) of the lead in children is stored in their bones (Barry, 1981) and the half-life of lead in human adult cortical bone is estimated to be 20 years (Rabinowitz, 1976; Borjesson, 1997). This skeletal lead can be an ongoing internal source of lead measured in blood even after external exposure and children's lead ingestion are reduced following lead remediation interventions. This was the case in an earlier study of children with much higher blood lead concentrations (geometric mean=63 µg/dL) who received inpatient chelation therapy and were monitored for several years following discharge to "lead-free" public housing and abated houses (Chisolm, 1985). Because the bone lead concentrations of R&M study children are unknown and the kinetics of lead mobilization from children's bones is not well understood, it is not possible to estimate the magnitude and duration of bone lead's contribution to children's blood lead concentrations measured in the post-intervention phase of this study. Children who reached the age of six months during follow-up are of particular interest because they are likely to have had minimal exposure to lead prior to enrollment (age six months).

Additionally, ambient lead levels in study neighborhoods may have mediated the children's blood lead responses to intervention and contributed to blood lead differences between the modern urban group and the other four groups. By design, the modern urban houses were all located in housing clusters built after 1979 and are presumably free of lead-based paint. The low lead concentrations found in interior dust, exterior dust, and soil support the notion that these control houses were associated with low ambient lead levels. The children in this group were, therefore, at low risk of exposure to lead in paint and in the general environment, compared to children living in the R&M houses and previously abated houses which are located in low-income lead-contaminated neighborhoods. Such neighborhoods often have housing in poor condition and in close proximity to abandoned and boarded houses.

Because hand-to-mouth activity is recognized as a major entry route for lead into pre-school children (Charney, 1982; Roels, 1980; Sayre, 1974), age and frequency of hand-to-mouth activity are other potential factors mediating children's blood lead response to an intervention. At the 24-month campaign, median ages of children across groups were 3.9 to 5.4 years, a range in which the frequency of mouthing behavior is likely to be less than in infants and young toddlers. This potential reduction in hand-to-mouth activity could account, in part, for the lack of statistically significant changes in blood lead concentration within individual R&M groups in children with baseline blood lead concentration <15 µg/dL, despite the substantial differences in dust lead exposure between and within groups over time.

The children with blood lead concentrations ≥15 µg/dL may have had higher blood lead concentrations due to more frequent hand-to-mouth activity. It also is possible they may have had a relatively greater contribution to their blood lead from current exposure rather than from bone lead, compared to children with blood lead concentrations <15 µg/dL. Therefore, their blood lead concentrations may have been more responsive to the reduction in lead exposure associated with the R&M interventions than children with lower baseline blood lead concentrations.

Refer to Section 7.0 for a more detailed presentation of these and other R&M study findings.

3.0 QUALITY ASSURANCE

3.1 System Audit

Laboratory and field activities were subjected to regular review to assure conformance with procedures proscribed in the Quality Assurance Project Plan (EPA, 1992). This ongoing audit focused on the sampling and analytical procedures used, their documentation, the training of field and laboratory personnel, and the adequacy of related facilities and equipment. Only minor problems, not directly related to data quality, were noted during the two years of follow-up.

3.2 Data Audit and Data Completeness

To verify the accuracy of the data used in this report, the quality control officer conducted a stratified random audit of 5 percent of the field and laboratory data generated during the first two years of this study. Prior to the audits, laboratory and data staff had completed independent checks of the data. The audit procedure involved the verification of information in the final data base against the original field and laboratory data. Samples to be audited were selected by computer using random number sequences. Sampling was stratified to ensure that samples were randomly selected to represent every analytical batch. Probably as a result of the extensive quality control effort prior to the audits by the quality control officer, the audits did not identify any errors.

Over 96.5 percent of the planned home visits were completed across all groups and campaigns. Over 99 percent of the samples collected during these visits were successfully analyzed and entered into the database. Thus, the study met and far exceeded the original 95 percent data completeness objective. In fact, of the 7,299 environmental and biological samples collected, the only unanalyzed samples were one sample voided in the laboratory, one misplaced set of samples from one house, and 44 extra field blanks.

3.3 Performance Audit

In order to assure that the sampling and analytical protocols employed in the R&M study yielded data of sufficient quality, a number of different types of quality control samples were included in the study design. These samples were designed to control and assess data quality in each phase of the data collection and analysis process, which were potentially subject to random and/or systematic error. Blank samples, including field blanks and method blanks, were included to assess procedural contamination by lead. Recovery samples, including standard reference materials, spiked samples, and calibration verification samples, were included to indicate the accuracy of analyses. Duplicate samples were used to indicate precision of analyses. Standard control charts were generated quarterly showing percent recovery of a standard reference material, percent recovery of spiked samples, spike/spike duplicate precision, initial calibration values, continuing calibration values, percent recovery of continuing calibration values, and drift of continuing calibration values within a run. Separate control charts were generated for each combination of sample matrix and analytical instrument used. For the more than 8,000 quality control samples included in these analyses, the control limit (±30 percent) was rarely exceeded for any quality control parameter. Data on field and method blanks also have been reviewed on a periodic basis as part of the performance audit.

In addition to these internal quality control efforts, the Kennedy Krieger Research Institute (KKRI) Trace Metals Laboratory has participated in external quality control programs for environmental lead samples and blood lead concentrations as a part of the R&M study. Beginning in September 1993, the laboratory participated in the Environmental Lead Proficiency Analytical Testing (ELPAT) program for environmental samples. This program is administered through the National Lead Laboratory Accreditation Program and is sponsored in part by EPA Office of Pollution Prevention and Toxics. Blind samples are analyzed quarterly; the KKRI Trace Metals Laboratory has been rated as "proficient" for the evaluation of lead in paint chips, soil, and dust wipes since joining the program. The Trace Metals Laboratory also participates in the Health Resources and Services Administration/Wisconsin Blood Lead Proficiency Testing Program. Three blind blood samples are analyzed every month as a part of this program. Since beginning this analysis in 1993 the KKRI laboratory has achieved a 100 percent accuracy rating for Graphite Furnace Atomic Absorption Spectroscopy (GFAA) analysis of blood lead for all rounds in which the laboratory participated.

Statistical Analyses of QC Data

The statistical analysis of the quality control samples included all samples from the initial campaign through the 24-month campaign, plus a small number of additional samples generated from additional follow-up campaigns. Because of the overlapping nature of the sampling campaigns in which samples were simultaneously generated and analyzed from several ongoing sampling campaigns, it is not possible to separate quality control analyses by sampling campaign. Statistical analyses of the quality control samples are included in Tables 2 through 4. With the exception of soil and water samples, the percent recovery of standard reference material and the percent recovery of spike and spike duplicates all fell within a tolerance interval of 70 percent to 130 percent. Precision was very high, with generally less than a 1 percent difference between spike and spike duplicate samples. With one exception, percent recovery of initial and continuing calibration samples fell within a tolerance interval of 90 percent to 110 percent. Drift was limited to an average of less than 2 percent over a run. Field and method blanks showed extraneous lead contamination of the samples to be, on average, trivial. No evidence of systematic contamination was observed.

Additional quality control analyses were conducted on the environmental sampling data to assess potential bias resulting from sampling conducted by different field personnel. No statistically significant differences were found between the estimates of dust lead loadings, dust lead concentrations, and dust loadings based on samples collected by the various members of the field staff, after controlling for surface type and study group.

Table 2: Descriptive Statistics And Tolerance Limits For Percent Recovery For SRM And Spiked Samples And Percent Differences Between Spike And Spike Duplicate Samples

Sample Type	Type of Analysis	Number of Samples	Minimum (%)	Maximum (%)	Mean (%)	Standard Error	Lower Limit 95% Tolerance Interval (%)	Upper Limit 95% Tolerance Interval (%)
Standard Reference Material (SRM)	ICP-DV[a]	549	76.27	153.64	92.96	0.41	73.26	112.66
	GFAA-DV	468	79.34	119.59	92.79	0.31	79.01	106.57
	GFAA-S[a]	20	43.14	108.39	91.47	3.23	51.66	131.28
	GFAA-W[a]	73	50.99	129.18	98.07	1.84	61.99	134.15
Spike/Spike Duplicate	ICP-DV SPIKE	548	82.33	119.92	96.91	0.20	87.15	106.67
	ICP-DV SPIKE DUPLICATE	548	77.09	121.03	96.74	0.21	86.59	106.88
	ICP-DV PERCENT DIFFERENCE	548	-20.99	13.29	0.19	0.12	-0.04	0.43
	GFAA-DV SPIKE	468	80.00	118.00	98.64	0.30	85.02	112.26
	GFAA-DV SPIKE DUPLICATE	468	79.00	139.00	98.64	0.33	83.97	113.31
	GFAA-DV PERCENT DIFFERENCE	468	-36.09	29.31	0.03	0.23	-0.41	0.48
	GFAA-S SPIKE	20	-263.00	289.00	82.23	21.44	-181.7	346.17
	GFAA-S SPIKE DUPLICATE	20	35.00	142.00	92.21	5.78	21.00	163.42
	GFAA-S PERCENT DIFFERENCE	20	-25.89	47.01	-0.03	3.06	-6.44	6.37
	GFAA-W SPIKE	73	72.80	117.80	97.39	0.99	78.10	116.68
	GFAA-W SPIKE DUPLICATE	73	40.80	120.60	97.14	1.31	71.53	122.75
	GFAA-W PERCENT DIFFERENCE	73	-7.41	64.87	0.53	0.97	-1.41	2.47

[a] DV = cyclone dust, S = soil, W = water

Table 3: Descriptive Statistics And Tolerance Limits For Percent Recovery For ICV And CCV

Sample Type	Type of Analysis	Number of Samples	Minimum (%)	Maximum (%)	Mean (%)	Standard Error	Lower Limit 95% Tolerance Interval (%)	Upper Limit 95% Tolerance Interval (%)
Initial Calibration Verification (ICV)	ICP-DV[a]	315	91.86	109.98	100.29	0.17	93.78	106.80
	GFAA-DV	130	92.50	110.00	103.71	0.33	95.50	111.92
	GFAA-S[a]	34	93.50	109.00	102.57	0.60	93.89	111.25
	GFAA-W[a]	62	96.00	110.00	103.52	0.42	95.77	111.28
Continuing Calibration Verification (CCV)	ICP-DV % TRUE VALUE	2113	88.74	112.70	98.70	0.08	90.96	106.43
	ICP-DV % DRIFT	2113	-13.95	14.53	-1.59	0.09	-1.78	-1.41
	GFAA-DV % TRUE VALUE	518	90.50	112.50	103.01	0.19	94.16	111.86
	GFAA-DV % DRIFT	518	-12.15	11.46	-0.89	0.19	-1.26	-0.52
	GFAA-S % TRUE VALUE	77	89.00	109.00	101.14	0.58	89.47	112.81
	GFAA-S % DRIFT	77	-13.88	9.23	-1.09	0.54	-2.17	-0.01
	GFAA-W % TRUE VALUE	174	90.50	110.00	102.88	0.34	93.21	112.55
	GFAA-W % DRIFT	171	-12.80	11.86	-0.39	0.33	-1.04	0.27

[a] DV = cyclone dust, S = soil, W = water

Table 4: Descriptive Statistics For Field Blanks And Method Blanks

Sample Type	Type of Sample	Number of Samples	Minimum (mg/L)	Maximum (mg/L)	Mean (mg/L)	Standard Error	Lower 95% CI for Mean	Upper 95% CI for Mean
Field Blank	Dust[a]	834	-22.50	142	1.78	0.29	-15.51	19.07
	Soil	108	0.01	2.59	0.17	0.03	-0.60	0.94
	Water	366	-0.40	92.00	1.37	0.27	-9.30	12.04
Method Blank	Dust	470	-0.40	207.00	2.34	0.46	-18.56	23.24
	Soil	20	-0.40	14.00	2.55	0.86	-8.10	13.19
	Water	73	-0.80	8.90	0.62	0.14	-2.06	3.31

[a] Field blanks are analyzed by ICP or GFAA

4.0 STUDY DESIGN AND SAMPLE COLLECTION PROCEDURES

The R&M study and the special state loan program that financed the R&M work targeted low-income houses in older neighborhoods where children are at high risk of lead-poisoning due to exposure to lead in dust and in deteriorating paint. It is important to emphasize that the R&M study was not designed as an intervention study in the homes of lead-poisoned children *per se*, although some study children did have blood lead elevations at baseline. Instead, the study started by identifying eligible intervention and control houses with eligible children. Further, since there were no requirements at the time for owners to reduce lead exposure in their rental properties in a proactive manner, participant families received R&M interventions that they likely would not have gotten otherwise. The eligibility criteria for children were based on age and other parameters, but not blood lead concentration (see Section 4.4). It is also important to recognize that the study was not designed to assess the specific effects of the various elements of the interventions (*e.g.*, provision of information to families) on the study outcomes. Instead, the study investigated the effectiveness of the R&M interventions as a whole.

The sections below provide an overview of the study design followed by descriptions of the R&M interventions, recruitment and enrollment procedures, selection criteria for houses and children, selected characteristics of the study houses, and sample collection procedures.

4.1 Overview Of Study Design

The R&M study had two main components (measurement of lead in venous blood and in environmental samples) and five groups of study houses. The first component was to obtain serial measurements of lead in venous blood of children in all five groups who were between the ages of six months and 48 months at enrollment and children who attained the age of six months during follow-up. The second component was to obtain serial measurements of lead in house dust, exterior soil, and drinking water in three groups of houses, each being subjected to one of three levels of R&M intervention and in two groups of control houses. Table 5 summarizes the types of data planned for collection by study group and by campaign. To allow for a better estimation of the post-intervention rate of re-accumulation of lead in dust and for periodic assessments of the need for further cleanups/repairs during the follow-up period, more frequent sampling campaigns were planned in the R&M groups during the first year of follow-up (Table 5). Blood lead and dust lead measurements were planned in all R&M study houses at each campaign, except blood lead was not collected at the immediate post-intervention campaign. Measurements of lead in exterior soil and drinking water were made at baseline, six months and 18 months. The study questionnaire, designed to obtain information on demographics and covariates that could influence lead exposure in the home (*e.g.*, hobbies and child behavior), was administered at six month intervals starting at enrollment.

Table 5: Data Collection Plan For Lead Paint Abatement And Repair & Maintenance Study

Study Group	Type of Data	Pre-Intervention /Enrollment Campaign	Post-Intervention Campaigns					
			Immediate	2 Months	6 Months	12 Months	18 Months	24 Months
R&M I	Blood	√		√	√	√	√	√
	Dust	√	√	√	√	√	√	√
	Soil	√	√		√		√	
	Water	√			√		√	
	Questionnaire	√			√	√	√	√
R&M II	Blood	√[a]	√[a]	√	√	√	√	√
	Dust	√	√	√	√	√	√	√
	Soil	√	√		√		√	
	Water	√[a]	√[a]		√		√	
	Questionnaire	√[a]	√[a]		√	√	√	√
R&M III	Blood		√[a]	√	√	√	√	√
	Dust	√	√	√	√	√	√	√
	Soil	√	√		√		√	
	Water		√[a]		√		√	
	Questionnaire		√[a]		√	√	√	√
Control Houses:	Blood	√			√	√	√	√
	Dust	√			√	√	√	√
Previously	Soil	√			√		√	
Abated and	Water	√			√		√	
Modern Urban	Questionnaire	√			√	√	√	√

Shading indicates data covered in this report

[a] Blood, questionnaire, and water samples were not collected in vacant houses until the family moved in following intervention.

R&M intervention houses (vacant and occupied) were identified in collaboration with owners and operators of low-income rental properties as explained in Section 4.3. Occupied houses that were eligible for R&M intervention were randomly assigned to receive either R&M I (low level intervention) or R&M II (intermediate level intervention). Vacant houses that were eligible for R&M intervention were randomly assigned to receive R&M II or R&M III (high level intervention). The R&M II intervention was designed to be performed in both occupied and vacant houses, and the randomization scheme was designed to ensure that equal numbers of houses were assigned to each R&M intervention level. However, two R&M Level II houses were reclassified to Level III on the basis of the actual work done in the house at the time of the intervention and one extra R&M III house was included in the study due to the availability of funds. The study thus had a total of 76 R&M houses as follows: 25 houses at R&M Level I, 23 houses at R&M Level II and 28 houses at R&M Level III.

The need for additional cleanups/repairs during the entire follow-up period was determined by a comparison of the follow-up dust lead loadings and blood lead concentrations with their corresponding pre-intervention levels. As mentioned previously, none of the interventions in individual houses failed during the two years of follow-up, that is, all or most of the dust samples showed lead loadings at, or below, pre-intervention levels. Consequently, no additional cleanup/repair work was performed on this basis. Further cleanups/repairs were to have been performed when dust lead loadings at most interior sites in a house re-accumulated to levels that exceeded pre-intervention levels. This assessment excluded interior sites with lower baseline dust lead loadings (*e.g.*, <100 $\mu g/ft^2$) that remained low at follow-up, despite small increases in their lead loadings. In contrast, clean-up/repair was considered for sites with high levels at baseline and at follow-up (*e.g.*, >25,000 $\mu g/ft^2$) where the follow-up level approached, but did not exceed, the corresponding baseline value.

The study also obtained serial measurements of lead in venous blood of children six months through 48 months of age at enrollment, and in house dust, soil, and drinking water in two groups of control houses. The first control group consisted of 16 houses drawn from a group of houses that received comprehensive lead-paint abatement in demonstration projects in Baltimore between May 1988 and February 1991 (Farfel, 1991 and 1994a). The second control group consisted of 16 modern urban houses built after 1979, which were presumably free of lead-based paint. The types and frequencies of measurement were the same in both control groups (Table 5). Two years of follow-up in the previously abated control group provided a means to measure the effectiveness of comprehensive abatement four years to six years after abatement.

It should be noted that the sample sizes of the control groups were reduced from 25 to 16 houses each, due to reductions in the scope and funding of the project. The number of control houses, rather than the number of R&M houses, was reduced because the former (and in particular the modern urban houses) were expected to have less inter-house variability with respect to both blood lead and dust lead. This was borne out in the study findings (EPA, 1996a and 1997). Furthermore, two types of houses were originally planned for inclusion in the modern urban control group: houses in clusters of urban houses built after 1979, and houses in scattered sites, that had been extensively rehabilitated after 1979. When the sample size of modern urban houses was reduced to 16 houses, only the former were included as the negative (no lead paint) control group (see Section 4.5 for additional descriptive information). It was expected that this type of cluster housing would reflect the lowest residential and ambient lead levels in the urban environment.

4.2 Repair & Maintenance Interventions and Comprehensive Abatement

The three levels of R&M interventions were designed in collaboration with a planning group that included representatives of a city program experienced in lead-based paint abatement work; non-profit housing organizations experienced in property management, renovation, and lead abatement; U.S. HUD; and the housing coordinator of the R&M study staff. An effort was made to apply what had been learned in past lead abatement projects (Farfel, 1990 and 1991).

R&M Levels I-III

The R&M interventions were financed by the Maryland Department of Housing and Community Development (DHCD) through a special loan program open to low-income owner-occupants and private property owners who rent their properties to low-income tenants. To meet DHCD loan eligibility requirements and the pre-requisites for R&M-type interventions imposed by the study, the three levels of R&M interventions were planned for study in lead-painted houses that had no structural defects and that were maintained according to the eligibility criteria listed in Section 4.4. The R&M intervention costs were capped by DHCD as follows: R&M I, $1,650; R&M II, $3,500; and R&M III, $6,000 to $7,000. The last range is due to program criteria and pre-existing program agreements. These cost caps necessitated prioritization and judgements about the R&M work to be done in any given study house. Additional work done by the property owner was taken into account and resulted in the reclassification of two R&M II houses to R&M III at baseline and three R&M I houses to R&M III during follow-up. It is important to note that the costs of the interventions in this project may not be generalizable to other settings and time periods due to differences in labor and material costs and overhead rates.

The three levels of intervention, described in detail elsewhere (EPA, 1992), are described briefly below and in Table 1. R&M I included the following elements: wet scraping of peeling and flaking lead-based paint on interior surfaces; limited repainting of scraped surfaces; wet cleaning with a trisodium phosphate detergent (TSP) and vacuuming with a high efficiency particulate air (HEPA) vacuum to the extent possible in an occupied house; the provision of an entryway mat; the provision of information to occupants; and stabilization of exterior lead-based paint to the extent possible, given the budget cap. The R&M II interventions included two key additional elements: floor treatments to make them smoother and more easily cleanable and in-place window and door treatments to reduce abrasion of lead-painted surfaces. In addition to all of this, R&M III included window replacement and encapsulation of exterior window trim with aluminum coverings as the primary window treatment, encapsulation of exterior door trim with aluminum, and the use of more durable floor and stair coverings (*e.g.*, vinyl tile) on some surfaces. R&M households received cleaning kits for their own cleaning efforts. The kits each included a bucket, sponge mop, sponges, a replacement sponge mop head, a TSP cleaning agent, and an EPA brochure entitled “Lead Poisoning and Your Children.” It should be noted that the Maryland Department of the Environment required that R&M III interventions, but not R&M I or R&M II interventions, meet Maryland’s interim post-abatement clearance levels based on wipe samples (*i.e.,* floors: 200 µg/ft^2; window sills: 500 µg/ft^2; window wells: 800 µg/ft^2).

<u>Elements of Comprehensive Lead-Paint Abatement</u>

The previously abated control houses received a comprehensive form of lead-paint abatement in demonstration projects in Baltimore between May 1988 and February 1991. These comprehensive abatements included the following elements:

- Addressing lead-based paint ($\geq$0.7 mg/cm^2 or $\geq$0.5% lead by weight), primarily using replacement and enclosure methods on interior surfaces;
- Minimal use of on-site paint removal methods;
- Fixing water leaks and other pre-existing conditions that would impede effective abatement;
- Installation of vinyl replacement windows and enclosure of the exterior window trim with aluminum coverings;
- Making floors smooth and more easily cleanable by the use of vinyl tile and sealants;
- Treating doors and stairways, including the replacement of lead-painted components;
- Cleaning by wet washing and the use of HEPA vacuum cleaners.

4.3 Recruitment and Enrollment

R&M study houses were identified from lists of addresses provided by collaborating owners of private low-income rental properties in Baltimore City and by City Homes, Inc., a non-profit housing organization, that owns and operates low-income rental properties to demonstrate methods of managing and maintaining such properties. The small number of owner-occupant properties in the R&M intervention groups (n=4) were identified through the KKRI's Lead Poisoning Prevention Program and outside sources. The previously abated houses were identified from lists of houses abated in past years as part of lead-based paint abatement demonstration projects conducted by Baltimore City and KKRI. The modern urban houses built after 1979 were identified by house-to-house visits conducted in multiple clusters of such housing in Baltimore.

The enrollment process was done in two stages: pre-enrollment and formal enrollment. These activities were undertaken by study field workers who conducted extensive home visits (1,100 visits to more than 650 modern urban, previously abated, and candidate R&M houses) during the spring and summer of 1992. More than 90 percent of households identified as potentially eligible for the study indicated an interest in participating. Unfortunately, demographic data are not available to compare those households to households which did not express interest in participating. This pre-enrollment activity yielded 100 interested and eligible households for formal enrollment. Formal enrollment entailed obtaining signed informed consent statements for study participation from parents or legal guardians for both environmental and biological sampling. Separate consent statements were obtained for each child enrolled in the study using forms approved by the Joint Committee on Clinical Investigation of the Johns Hopkins Medical Institutions.

Between the time of formal enrollment and the commencement of the initial data collection campaign in January 1993, some enrolled households became ineligible, primarily due to the children growing too old to participate and the families moving to other dwellings. In some cases, the losses reinitiated pre-enrollment activity to identify an additional pool of potential study participants. The initial environmental sampling campaign in the modern urban and previously abated control houses was performed between January 1993 and July 1993. The baseline environmental sampling in R&M houses was conducted between March 1993 and November 1994.

4.4 Selection Criteria For Houses and Children

Houses and children were selected for participation in the study based on a rigid set of criteria. The first set of selection criteria listed below was applied to all five study groups. Additional selection criteria were applied to the three R&M groups and to the previously abated control group.

<u>Selection criteria applied to all five study groups</u>:

- House size was approximately 800 ft^2 to 1,200 ft^2.

- The house was structurally sound without pre-existing conditions that could impede or adversely affect the R&M treatments and the safety of the workers and field staff (*e.g.*, roof leaks or unsafe floor structures). This criterion eliminated substandard housing in need of major renovation and, therefore, not suitable for R&M-type interventions. It also allowed a house to qualify for the special state loans that financed the R&M interventions. The household also had to meet income eligibility requirements of the state loan program.

- Utilities (heat, electric, and water) were available to facilitate interventions and field sampling.

- Each household included at least one child who was six months through 48 months of age at enrollment and was not mentally retarded or physically handicapped or had restricted movement. The house also had to be the child's primary residence (*i.e.*, the child was reported to spend at least 75 percent of time at the address). Also, at time of enrollment the child's family had no definite or immediate plans to move.

- The house did not contain a large amount of furniture. This criterion allowed for dust collection in all houses, as well as intervention and cleanup in occupied R&M houses.

<u>Additional selection criteria applied to R&M houses</u>:

- House contained lead-based paint (defined in Maryland as $\geq$0.7 mg Pb/cm^2 or $\geq$0.5 percent lead by weight, as determined by wet chemical analysis) on at least one surface in a minimum of two rooms or, in the absence of testing, was constructed prior to 1941 when lead-based paints were commonly used (HUD, 1990).

- Interior dust lead loadings, prior to intervention, exceeded Maryland's interim post-abatement clearance levels (*i.e.*, 200 µg/ft^2 for floors, 500 µg/ft^2 for window sills, and 800 µg/ft^2 for window wells) at a minimum of any three locations (Annotated Code of Maryland, 1988).[d]

- The house had 12 or fewer windows needing R&M work. This was to allow for the implementation of the R&M interventions, given limited resources.

<u>Additional selection criterion applied to previously abated houses</u>:

- At least two pairs of pre-abatement and immediate post-abatement dust-wipe lead measurements from the same floor, window sill, and window well surfaces were available from previously collected data. This ensured that data were available to the R&M study on pre- and post-abatement baseline dust lead levels in these control houses.

4.5 Characteristics Of Study Houses and Participants

The R&M houses and the previously abated houses were scattered throughout older residential neighborhoods in Baltimore. These study houses were built prior to 1941. More than 98 percent of the R&M houses and 100 percent of previously abated houses were rowhouses (see the report cover), which constitute the predominant type of housing in inner-city Baltimore neighborhoods. As mentioned previously, the 16 modern urban houses are rowhouses located in clusters built after 1979. The clusters of modern urban houses, which served as the sampling frames for this study, were all located in, or are adjacent to, urban housing neighborhoods constructed prior to 1941. Each cluster had multiple rows of housing built after 1979 and the rows generally extended the length of a city block. The characteristics of the study houses were typical of housing in low-income neighborhoods in Baltimore. Unfortunately, data do not exist to allow a comparison of dust lead levels in study homes to those in city homes in general.

Study houses generally were similar in terms of characteristics that might influence patterns of dust movement into and within a house (*i.e.*, overall size, number of windows, house type and design, condition, degree of setback from the street, and the presence of porches and yards) (EPA, 1996a). The selection criteria ensured that the study houses would be similar in terms of size, number of windows, and, to some degree, overall condition. With regard to housing type, all five groups of houses consisted primarily of two-story rowhouses (not located at the end of the row) with two or three rooms on each level. Floor plans were produced for each study house to facilitate the sample collection activities. The proportion of carpet samples in composites was, on average, very low - essentially zero - in R&M I, R&M II, R&M III, and previously abated houses. On average, the proportion of carpets making up floor dust composites in modern urban houses was very high, averaging close to 100 percent. Despite this, some differences were noted in the distribution of carpets between first and second stories in all groups.

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[d] In 1990, these interim clearance levels were adopted by HUD (1990). In 1995, HUD revised its interim clearance standard for floors to be 100 μg/ft^2 (HUD, 1995).

Further, most study houses did not have porches (84 percent), were not located on narrow alleys (77 percent), and were not set back far from the street (77 percent). Houses with minimal setback had no front yards and entryways leading directly from the sidewalk, or from stairs ascending directly from the sidewalk. The other 23 percent of study houses were more than minimally set back from the street, primarily due to the presence of porches or small front yards. Only four houses (3 percent) were classified as being set back from the street by more than a modest amount as described above. Unlike the other four groups of houses, most of the modern urban control houses had yards in the front or back of the house. For this reason, exterior soil was available for collection at baseline from 63 percent of the modern urban houses, as opposed to only 21 percent of the R&M houses and 19 percent of the previously abated houses.

As reported previously (EPA, 1996a), a comparison of the 75 R&M houses to 27 R&M candidate houses that were sampled but not included in the study revealed no evidence of selection bias based on environmental lead concentrations, lead loadings, dust loadings or the blood lead concentrations of resident children.

4.6 Sample and Data Collection Procedures

Venous blood was collected from study children at the Kennedy Krieger Research Institute's Lead Poisoning Clinic by a pediatric phlebotomist into 3 mL Vacutainers® with EDTA added as an anticoagulant. Information on study children and their households was collected using a structured interview questionnaire (EPA, 1992). Trained field teams administered the questionnaires and collected all environmental samples, including quality control (QC) samples.

Settled house dust was collected using a modified high-volume cyclone sampler originally developed for EPA for the evaluation of pesticide residues in house dust (Research Triangle Institute, 1990). The modified device, referred to as the R&M cyclone, is described in detail and characterized elsewhere (Farfel, 1994b and 1994c). The device consists of a Teflon®-coated cast aluminum cyclone attached to hand-held Dirt Devil ® vacuum as the air mover for the system. A 100 mL Teflon® microwave digestion liner was used as the sample collection container to eliminate a sample transfer step in the laboratory, thereby reducing the risk of sample loss.

The sampling plan for settled dust included the collection of three composite floor dust samples in each of the houses at each campaign: one floor composite in rooms with windows on the first story, one floor composite in rooms with windows on the second story, and one composite in first and second story rooms without windows. Each composite was composed of samples collected from two randomly selected 1 ft^2 (929 cm^2) perimeter floor locations in each appropriate room. If a randomly selected location were carpeted or covered with an area rug, this information was recorded on the sample collection form and the carpet or rug was sampled using the R&M cyclone. Settled dust also was collected in two composite window sill samples and two composite window well samples in each house at each sampling campaign. Samples were composited by story from all windows available for sampling. Examples of windows not available for sampling were those with window air conditioners and those blocked by furniture. Settled dust also was collected as individual (*i.e.*, not composite) samples from horizontal portions of air ducts, from interior and exterior

entryways, and from the main item of upholstered furnishing in each house.
Data on lead loadings, lead concentrations and dust loadings for the various sample types are presented in Appendix B, Figures 1-12, and Section 7.0.

Three individual soil core samples were collected from the top 0.5 inch (1.3 cm) of soil from three randomly selected locations at the drip-line and then combined as one composite sample. Each soil core was collected into a polystyrene liner using a six-inch (15.2 cm) stainless steel recovery probe. Drinking water samples were collected as two-hour fixed-time stagnation samples from the kitchen faucet. This procedure involved running the cold water for at least two minutes to flush the pipes and, after a two-hour interval, collecting the first flush of water in a 500 mL polyethylene bottle. A list of field sample types is provided in Table 6.

Table 6: Types Of Field Samples

Sample Type	Sampling Locations/Specifics
Perimeter Floor Composite Settled Dust	First story and second story rooms with windows; rooms without windows
Window Sill Composite Settled Dust	First and second story
Window Well Composite Settled Dust	First and second story
Air Duct/Upholstery Settled Dust	Upholstery was sampled if air ducts were unavailable
Interior Entryway Settled Dust	Not directly on entryway mat
Exterior Entryway Settled Dust	Not directly on entryway mat
Soil Core	Drip-line composite and property boundary composite
Drinking Water	Kitchen faucet
Field QC	Blanks and duplicates for all field sample types

<u>Provision of Information to Families, Reporting and Follow-up</u>

Participating families were informed by letter of the results of dust lead tests from each campaign. Results of dust tests were provided on a qualitative basis with recommendations for housekeeping priorities to control lead in dust (Appendix A). Parents/guardians were also informed by letter and/or by telephone of their children's blood lead test results from each campaign (Appendix A). The letter recommended that parents share the results with the child's primary care provider. As required by Maryland law, all blood lead test results were reported to the Maryland Childhood Blood Lead Registry operated by the Maryland Department of the Environment (MDE). MDE in turn provided information to the Baltimore City Health Department's Lead Poisoning Prevention Program for routine case management and follow-up. Thus, this study added to, but did not replace, usual medical care.

5.0 LABORATORY ANALYSIS PROCEDURES

Interior and exterior settled dust, exterior soil, water and venous blood samples were analyzed at the Kennedy Krieger Research Institute Trace Metal Laboratory using established analytical methods. Closed vessel microwave digestion was used for dust, soil, and water samples, according to modified SW 846 Methods 3015 and 3051. Analysis of dust digestates was performed using Inductively Coupled Plasma-Atomic Emission Spectrometry (ICP), according to SW 846 Method 6010 and/or Graphite Furnace Atomic Absorption Spectrometry (GFAA), according to SW 846 Method 7421. Soil and drinking water were analyzed by GFAA according to SW 846 Method 7421. Venous blood was analyzed by GFAA and by anodic stripping voltammetry (ASV) (Bannon, 1994). Table 7 summarizes these procedures.

Table 7: Summary Of Laboratory Procedures

Sample Type	Pre-Preparation	Preparation	Analysis
Dust	Drying and gravimetrics	Microwave digestion using 1:1 HNO_3: H_2O	ICP/GFAA[a]
Soil	Drying, sieving and homogenization	Microwave digestion using 1:1 HNO_3: H_2O	GFAA
Drinking Water	Acidified	Microwave digestion using 1:1 HNO_3: H_2O	GFAA
Blood	Stabilized in EDTA after collection	Addition of matrix modifier/Triton X-100 solution	GFAA/ASV[b]

[a] Samples with lead concentrations below the limit of quantitation of the ICP instrument were analyzed by GFAA.
[b] ASV was used in addition to GFAA for rapid reporting of blood lead results.

6.0 DATA PROCESSING AND STATISTICAL ANALYSIS PROCEDURES

6.1 Data Processing

Data analyzed as a part of this study were derived from field collection forms, laboratory instruments, and questionnaires. Raw data of all types were transferred to the data manager who uploaded the data to a VAXStation 3100 computer for later analysis. A summary of the data processing steps employed for the three sources of data is presented below.

- The field data consist of all data recorded on the field collection forms for settled dust, soil, and drinking water samples, as well as room and window inventory data and general study data. Data were entered twice for verification from the field forms into ASCII data files by a commercial data entry firm. These raw data files were transferred to the data management team for management, storage, and later analysis. Field data forms were checked for completeness and accuracy by the outreach coordinator and data manager prior to data entry. Data were verified again by laboratory staff from final SAS® file printouts.

- Laboratory data were electronically stored by each laboratory instrument. Gravimetric data (tared and loaded weights for dust and soil samples) were generated and stored by the Mettler balance. Lead concentration measurements for dust samples were made and recorded by the ICP. Lead content in drinking water, soil, and blood, as well as dust samples with low lead concentrations, were measured by GFAA. Electronically stored laboratory data from the Mettler, ICP, and GFAA instruments were imported to Paradox® (v.4.0) by laboratory staff for tracking of samples. Paradox® data were then converted to ASCII files by the data management team for uploading to the VAXStation. A SAS® program read in the laboratory data for environmental and blood samples and created SAS® data sets for data analysis. The data were verified again by laboratory staff from final SAS® file printouts.

- Questionnaire data forms were entered twice by a data entry firm into ASCII data files. These raw data files were verified in-house and transferred to the data manager. An SAS® program read in the raw data and created SAS® data sets for analysis.

6.2 Data Summary

Environmental dust data from four surface types (perimeter floor, window sill, window well, and interior entryway) included in each of the seven data collection campaigns (baseline, post-R&M, two months, six months, 12 months, 18 months and 24 months post-R&M) are included in this report, as well as data collected less frequently (*i.e.*, air duct dust, upholstery dust, exterior entryway dust, soil, and water). Data completeness goals were met (Section 3.0). Tables 8 and 9 display the types and numbers of 24-month campaign samples planned, collected, and analyzed for lead, by group, for the 97 houses included in the 24-month data analysis. Table 8 also provides information by sample type across all campaigns.

Table 8: Types And Numbers Of Samples Collected And Analyzed For Lead As A Part

Of The 24-Month Campaign And Across All Campaigns

Sample Type	Planned per House	Samples Collected and Analyzed for Lead in 97 Houses at 24 Months [d]	Unobtainable Samples in the 97 Houses at 24 Months	Samples Collected and Analyzed Across all Campaigns
Perimeter Floor Dust Composite in Rooms with Windows	2[a]	196	0	1,410
Perimeter Floor Dust Composite in Rooms without Windows	1	52	45[c]	387
Window Sill Dust Composite	2[a]	192	2	1,387
Window Well Dust Composite	2[a]	184	10	1,347
Interior Entryway Dust	1	97	0	697
Exterior Entryway Dust	n/a	n/a	n/a	341
Air Duct Dust	1[b]	54	2	193
Upholstery Dust	-[b]	41	0	217
TOTAL DUST	9	816	59	5,979
Soil Core - drip line &property boundary	n/a	n/a	n/a	125
Drinking Water	n/a	n/a	n/a	366
Venous Blood	1/child	123	-	775
GRAND TOTAL	$\geq$10	939	59	7,245

a One composite sample was obtained per story. Some houses had samples in basements used as living spaces.

b Upholstery samples were collected if air duct samples could not be obtained.

c 45 houses did not have rooms without windows.

d Does not include one house for which the samples are missing and three R&M I houses that were reclassified to R&M III based on work done by their owners between the 18-month and 24-month campaigns. The 24-month data from these reclassified houses were not used in the data analysis.

n/a = not applicable

Table 9: Types And Numbers Of Samples Collected By Group (Excluding QC Samples) As A Part Of The 24-Month Campaign[a]

Sample Type	Collected in 14 Modern Urban Houses	Collected in 13 Previously Abated Houses	Collected in 21 R&M I Houses[b]	Collected in 22 R&M II Houses	Collected in 27 R&M III Houses
Perimeter Floor Dust Composite in Rooms with Windows	29	26	43	44	54
Perimeter Floor Dust Composite in rooms without windows	3	6	14	15	14
Window Sill Dust Composite	28	26	40	44	54
Window Well Dust Composite	28	26	35	42	53
Interior Entryway Dust	14	13	21	22	27
Exterior Entryway Dust	-	-	-	-	-
Air Duct Dust	10	9	8	12	15
Upholstery Dust	4	4	12	9	12
TOTAL DUST	116	110	173	188	229
Soil Core - drip line	-	-	-	-	-
Drinking Water	-	-	-	-	-
Venous Blood	18	25	19	29	32
TOTAL	134	135	192	217	261

a Two R&M II houses were reclassified to R&M III on the basis of the actual work done in the house at the time of intervention.

b Includes three houses upgraded from R&M I to R&M III by property owner between the 18-month and 24-month campaigns. The 24-month data from these three houses were not included in the data analysis.

Two of the 16 modern urban houses and three of the 16 previously abated houses were lost to follow-up when five families withdrew from the study (Table 10). None of the 76 R&M houses were lost to the study during the two-year period of follow-up. It should be noted that three R&M I houses were upgraded independently by the property owners between the 18-month and 24-month campaigns (Table 10). These three houses were reclassified as R&M III houses based on the actual work done and sampled as R&M III houses during the 24-month campaign; however, the 24-month data on these three reclassified houses were not included in the data analysis for this report. None of the other study houses are known to have had any major renovations or repairs during the two-year period of follow-up. One R&M I house had its front and back doors replaced during the first year of follow-up due to break-ins that damaged the original doors, and in another house, the wallpaper was removed by the occupants from the first floor rooms using a steam process.

Most of the original 108 study households (n=70; 65%) resided in the study houses during the entire two-year period of follow-up. Moves occurred most often in R&M I houses and R&M II houses and least often in the modern urban control houses (Table 11). Furthermore, four study houses had two family moves during follow-up. Through the 24-month campaign, 83 percent (35 of 42) of the families that moved were replaced by the next family that moved into the house (Table 11). At the time of the 24-month campaign, three houses were vacant, pending occupancy or repairs. Despite the success in gaining the participation of the new move-in families, they had fewer study children than the original families. However, the study gained sixteen children who became of age ($\geq$6 months) for blood lead testing during follow-up (Table 11). Section 7.1 provides blood lead data for these sixteen children by study group.

6.3 Statistical Analysis

This section describes the statistical methods employed in the analysis of data from the two years of follow-up. The first section describes the methods used to generate descriptive statistics and graphical displays of the data. The second section provides an overview of the statistical method used for the analysis of longitudinal data. The last section describes the use of factor analysis as a method for combining individual sample readings in a house and specifies the longitudinal models fitted to the dust and blood data.

SAS PROC MIXED software (version 6.09E) was used for longitudinal data analysis (SAS, 1990). Interpretation of the estimates obtained by the mixed model obey the usual rules of interpretation of regression coefficients, *i.e.*, the coefficient of a covariate is the expected change in the response variable associated with a unit change in the covariate in the presence of the other covariates. When the covariate is a dummy variable, a unit change in the covariate corresponds to the expected difference between the response at the level of the covariate compared to the omitted level.

Table 10: Numbers Of Houses, Reclassifications, And Houses Lost To Follow-Up During The First Two Years Of Follow-Up

Study Group	No. Houses at Outset	No. Houses Upgraded by Owners During Follow-Up and Reclassified	No. Houses Lost to Follow-Up	No. Houses Sampled at 24-Month Campaign	No. Houses Remaining in the Extended Follow-Up Study
R&M I	25	3[b]	0	21[c]	22
R&M II	23[a]	0	0	22[c]	23
R&M III	28[a]	0	0	31[b]	31[b]
Previously Abated (1989 to 1991) using Comprehensive Methods	16	0	3	13	13
Modern Urban - built after 1979	16	0	2	14	14
TOTAL	108	3	5	101[b]	103

a Two R&M Level II houses were reclassified to Level III on the basis of the actual work done in the house at the time of the intervention. The total also includes one extra R&M III house that was added to the study.

b The total includes the three R&M Level I houses that were upgraded to R&M III by the property owners between the 18-month campaign and the 24-month campaign. In another case, the house dust samples were missing, leaving 97 houses for data analysis at 24 months..

c One R&M I house and one R&M II house could not be sampled at 24-months due to difficulties in gaining access to the home. These two houses remain active in the extended follow-up study.

Table 11: Family Moves, Reoccupancies, And New Subjects Enrolled Between The Initial Campaign And The 24-Month Campaign

Study Group	Moved		Replaced		Children reaching six months of age during follow-up
	No. Households (No. Houses)	No. Children[a]	No. Households (No. Houses)	No. Children	No.
R&M I (25 houses)	13 (12)	23	12 (11)	7	5
R&M II (23 houses)	13 (10)	21	11 (8)	16	2
R&M III (28 houses)	8 (8)	12	8 (8)	7	4
Previously Abated (16 houses)	7 (7)	7	4 (4)	7	2
Modern Urban (16 houses)	1 (1)	4	0 (0)	0	3
Total	42 (38)[b]	67	35 (31)	37	16

[a] Includes children/families who moved although other members of household remained.

[b] This number represents 33 percent of the original 108 study houses.

For data analysis purposes, lead values below the instrument detection limit (IDL) were coded as the IDL/√2 (Hornung, 1990). For lead values less than the limit of quantitation (LOQ), but greater than the IDL, the observed value was used in the data analysis. Also, one child in a previously abated house had a blood lead increase to a concentration of 53 µg/dL at the 12-month campaign and was provided with chelation therapy; identified lead-based paint hazards were addressed. This child was an outlier in this study and was excluded from the statistical data analysis relating blood lead to dust lead.

Descriptive Statistics

The study outcome variables were dust lead concentration (μg/g), dust lead loading (μg/ft^2), dust loading (mg/ft^2) and blood lead concentration (μg/dL). The main study variables included study group, data collection campaign, type of environmental sample (*e.g.,* dust, water), and surface type (*e.g.,* floor, window sill, window well, entryway, upholstery). A Shapiro-Wilk Test indicated that the distributions of the dust and blood lead data were skewed (Shapiro, 1965). As expected, use of the log transformation reduced the degree to which the data were skewed and produced histograms and boxplots that were approximately normal (Section 7.1 Figures 1-13). Descriptive statistics on blood and dust were produced after transforming the data using the natural logarithm (ln).

A further characteristic of the data set is the repeated measures from a house, which violate the assumption of independence invoked for most analyses. To overcome this problem, a mixed-effects model was used to account for the correlation of samples within a house. These calculations result in a better estimate of the mean and confidence interval for the settled dust from floors in rooms with windows, window sills, window wells, and children's blood. These calculations were done by study group and surface type.

Descriptive statistics for all dust sample types at 24 months of follow-up are presented in Appendix B (Tables B-1 to B-3). Tables 15-17 display descriptive statistics for blood, soil and water. Since multiple observations were available in each of the houses for settled dust from window sills, and window wells, floors in rooms with windows, as well as for children's blood, additional analysis was performed using SAS® PROC MIXED with house as a random effect to address the issue of clustering *(i.e.,* multiple observations per house). Geometric mean values, standard errors, and 95 percent confidence intervals were obtained using the intercept models fitted separately for each study group, surface type (floors in rooms with windows, window sills, window wells), and matrix (dust, blood).

Side-By-Side Boxplots

Side-by-side boxplot figures with median traces are presented in this report as a means of displaying lead levels across campaigns within and between study groups. In a boxplot display, 50 percent of the data is contained in the box shown in the figure; the bottom of the box is the lower quartile and the top of the box is the third quartile, the horizontal line inside the box represents the sample median. The vertical lines extending from the box represent the expected lower and upper range of the data, based on the variability of the central portion of the data. The fences are 1.5

interquartile ranges from the upper and lower edges of the box. Extreme values are indicated by an asterisk (Tukey, 1977). The widths of the boxes in any given side-by-side boxplot are proportional to the number of observations. The descriptive statistics presented in this report include "extreme values" that are indicated by the symbol '*' in the boxplot displays.

Statistical Method for Analysis of Longitudinal Data

Statistical methods for the analysis of longitudinal data have developed rapidly over the last decade (Laird, 1982; Zeger, 1986 and 1988; Waternaux, 1989; Liang, 1986; Moulton, 1989; Royall, 1986). These methods, which are natural extensions of multiple regression and analysis of variance, are extremely flexible. Current longitudinal methods allow for the inclusion of random and fixed effects, longitudinal (time-dependent) covariates and constant covariates, as well as for discrete and continuous covariates, all in a multiple regression context. In this study, for example, the following types of covariates were included in the data analysis:

- age of child - fixed time dependent covariate
- campaign - fixed time dependent covariate, discrete
- child - random effect, discrete
- dust lead - fixed time dependent continuous covariate
- house - random effect, discrete
- season - fixed discrete covariate
- study group - fixed effect, discrete

The response variable modeled was dust lead reading or blood lead concentration (log-transformed). These response variables, as well as their associated covariates, have been observed at times described in Table 5.

The longitudinal regression models in this study follow a general format:

$$y = X\beta + Zb + \epsilon \qquad \text{(Eq.1)}$$

where y is a vector of responses over time for a house, β is an unknown vector of fixed-effects parameters with a known design matrix, X, and b is an unknown vector of random-effects parameters with a design matrix, Z, and ϵ is an unknown error vector.

Estimates of the parameters in the overall model are obtained using the methods outlined in the published papers cited above. The essential feature of these methods is the use of weighted least squares with a "working" estimate of the covariance matrix followed by iteration with an updated estimate of the covariance matrix until convergence. The estimate of the variance-covariance matrix of the fixed effects is robust, in the sense that it is consistent, regardless of the form of the "working" estimate of the covariance matrix. The model for blood lead is similar to the above model, specified for each child.

Our primary interest in this study is in the parameters of the model that represent the effect of R&M interventions on dust lead and blood lead. The fact that this model allows estimation of these parameters in the presence of heterogeneity between houses and temporal correlation, and produces variance estimates that are robust, is extremely important.

The general nature of the model makes it ideal for a study of this type where there is the potential for unbalance. Since the model is house-specific or child-specific, depending on whether dust lead or blood lead is being modeled, we do not require that the number of observations through time be equal. Thus, should a child move or otherwise be eliminated from the study, the house data can be analyzed while the data for that child can be included up to the point of departure. Should another child be entered into the study at that house, his or her blood lead readings can be included in the blood lead analysis for the remainder of the study, thus providing partial information for that child. The common residence of the children is included in the house covariate, which allows for correlation structure between these observations.

Age-related effects in the analysis of blood lead concentration responses need to take into account the fact that blood lead is not linearly related to age, since it tends to increase between six months and two years and decrease slowly among children over two years of age. This is done by the use of linear and quadratic terms for age in the model. The presence of several children in a house, which introduces another source of correlation, (*i.e.*, between children in the same house) is accounted for by using the house as a random effect, which introduces the required correlation.

Specifications of Longitudinal Models for Dust

In the analysis of the data from the two years follow-up, we fit the statistical models proposed in the Quality Assurance Project Plan (EPA, 1992). The results of the compositing self study indicated that an overall measure of lead exposure could be considered with little loss of information (Farfel, 1995). This finding held for all dust endpoints and suggested that the readings from multiple sample sites in a house can be combined to produce an overall measure. Consequently, we explored the use of factor analysis as a method for combining individual sample results. The use of the results of exploratory factor analysis to guide the construction of variables for analysis is a standard approach used in data analysis.

Factor analysis (and its close relative, principal components) is often used to combine different measures in order to obtain one or two summary measures. The factors (latent variables) are assumed random in this approach, similar to the representation in a measurement error model. The two factors presented below were derived as those linear combinations of the basic environmental lead measures (see below) which account for most of the variability in environmental lead measurements. A factor score consists of the values that the factor assumes for a particular house at a given campaign. Thus they represent a derived measure of lead exposure.

Our general approach for combining dust data is outlined below:

- Data for floors in rooms with windows, window sills and window wells were used in the analysis. These data were mathematically composited across stories in a house by calculating weighted averages for each of the three dust endpoints, for each house, and for each campaign.

- The weighted averages were transformed using natural logarithms.

- Factor analysis was first performed for each dust endpoint by campaign and then again not by campaign. The latter results were then used in the longitudinal analysis. These steps were repeated anew for each analysis because of the different combination of study groups and campaigns for intervention and for control houses.

Occasionally, a composite was incomplete because a sill or well was not accessible. On a very few occasions, all sills or wells in a single story were inaccessible and thus, no composite value was available. If both first- and second-story composites were missing, no attempt was made to estimate missing data.

The results indicate that:

- The first factor (factor1) accounts for 63 percent to 83 percent of the variability of environmental dust lead across campaigns, when all five groups are analyzed together, and 53 percent to 72 percent of the variability, when the three R&M groups are analyzed separately (Table 12).

- The second factor (factor2) characterizes the difference between the floor lead measurements and the window sill and window well lead measurements and accounts for 11 percent to 24 percent of the variability, when all five groups are analyzed together, and 21 percent to 31 percent of the variability, when the three R&M groups are analyzed separately (Table 12).

The variability of the dust readings accounted for by the factor loadings have remained relatively stable over study groups and campaigns (Table 12). Factor patterns by surface type are displayed in Appendix D, Tables D-1 and D-2. These table show the pattern of factor loadings, so that, for example, the first factor is essentially an equi-weighted average of floor, window sill and window well exposure. The second factor generally contrasts floors with window sills and window wells. The factor patterns for all five groups were stable over time, except for factor2 at the 24-month campaign (Table D-1). The factor patterns for the three R&M groups by surface type across campaigns also were consistent over time, except for factor2 at the initial campaign (Table D-2). The latter may be different due to the fact that half of the R&M houses were vacant at the time of the initial campaign and/or to an intervention effect on factor patterns.

Table 12: Variability Accounted For By Factor Loadings Across Campaigns

Five Study Groups Combined:

Dust Measure	Initial Campaign		Six-Month Campaign		12-Month Campaign		18-Month Campaign		24-Month Campaign		Overall	
	factor1	factor2	factor1	factor2	factor1	factor2	factor1	factor2	factor1	factor2	factor1	factor2
Lead Loading	.82	.12	.69	.22	.65	.24	.69	.23	.63	.21	.78	.15
Lead Concentration	.83	.11	.73	.20	.66	.21	.72	.21	.73	.16	.76	.16
Dust Loading	.68	.21	.60	.23	.55	.31	.55	.29	.50	.30	.69	.20

Three R&M Groups:

Dust Measure	Initial Campaign		Post-Intervention Campaign		Two-Month Campaign		Six-Month Campaign		12-Month Campaign		18-Month Campaign		24-Month Campaign		Overall	
	factor1	factor2	factor1	factor2	factor1	factor2	factor1	factor2	factor1	factor2	factor1	factor2	factor1	factor2	factor1	factor2
Lead Loading	.54	.29	.65	.21	.60	.30	.64	.27	.58	.31	.64	.28	.53	.27	.72	.20
Lead Concentration	.55	.27	.59	.29	.60	.27	.63	.28	.54	.31	.64	.28	.59	.25	.64	.25
Dust Loading	.58	.26	.54	.26	.55	.31	.61	.25	.55	.32	.58	.29	.50	.30	.73	.18

Appendix D also shows that the factor patterns are consistent within campaigns for the three types of dust measurements. Both factor1 and factor2 are normally distributed.

Given the stability of the factors over time, they were used as the variable to measure environmental lead levels. The first factor was used as the dependent variable in the longitudinal data analysis of the three dust endpoints. This factor reflects the campaigns up to, and including, the 24-month campaign. We found that the use of the first factor in the data analysis explains more of the variability in the dust endpoints, as compared to raw average or to weighted average measures. Consequently, the following models were fit to the dust data (see Table 13 for definitions of variables).[e]

Environmental Model:

$$\begin{aligned} factor1_{ijkl} = \beta_0 &+ \beta_1 * season_{ij} + \beta_2 * group_{ik} \\ &+ \beta_3 * campaign_l + \beta_4\, group_{ik} * campaign_l \\ &+ b_i * house_i + \epsilon_{ijkl} \end{aligned} \qquad \text{(Eq.2)}$$

where,

"i" refers to house, "j" to season, "k" to study group, "l" to campaign, "group*campaign" to the interaction of group and campaign. Following standard practice, regression coefficients corresponding to fixed effects are denoted by Greek letters, while regression coefficients corresponding to random effects are denoted by Roman letters (*e.g.*, b).

This model was fit to the lead concentration, lead loading and the dust loading data. The models were run using all five study groups and then again using just the three R&M groups in order to include the immediately post-intervention and two-month campaign data (which apply only to the R&M groups) in the analysis.

Specifications of Longitudinal Models for Blood Lead

To address the study objectives with regard to blood lead, we fit two main types of models to the data. The first model, referred to as the exposure model, was used to characterize the relationship between blood lead and dust lead (both dust lead concentrations and lead loadings). In this model, the two dust lead factors were included as independent variables, along with demographic and behavioral variables. The second model, referred to as the comparison model, was used to investigate blood lead concentrations across groups and within groups over time.

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[e] Our exploratory analysis indicated that the covariance structure varied little over time. Therefore, when fitting the longitudinal models using SAS Proc Mixed, we used the random statement that built in the necessary covariance structure.

Table 13: Definitions of Variables

Variable	Definition
Factor1	Linear combination of floor, window sill and window well data (composite measure of exposure in a house).
Factor2	Linear combination of floor, window sill and window well data (represents the difference between floor and window values).
Age	Child's age in months
Mouthing	The sum of four questionnaire variables dichotomized into a low/high variable
Season	Fall: September 21 through December 20 Winter: December 21 through March 20 Spring: March 21 through June 20 Summer: June 21 through September 20

The two models are as follows:

<u>Exposure Model</u>

$$
\begin{aligned}
ln(PbB)_{iklm} = {} & \beta_0 + \beta_1 * factor1_{iklm} + \beta_2 * factor2_{iklm} \\
& + \beta_3 * age_{iklm} + \beta_4 * age^2_{iklm} + \beta_5 * summer_{iklm} \\
& + \beta_6 * campaign_l \\
& + b_i * house_i + b_{m(i)} * child_{m(i)} + \epsilon_{iklm} \qquad \text{(Eq.3)}
\end{aligned}
$$

where,

"i" refers to house, "k" to group, "l" to campaign, "m" to child within house, "group*campaign" to the interaction of group and campaign. Regression coefficients corresponding to fixed effects are denoted by Greek letters, while regression coefficients corresponding to random effects are denoted by Roman letters (*e.g.*, b).

The initial campaign blood and dust lead values for children who moved into the vacant R&M II and R&M III houses after intervention were excluded from the exposure model along with any other children who had not occupied their homes for at least two months. Their initial blood lead values at the time they moved in and first occupied the houses post-intervention reflect body burdens associated with exposures in their past living environments, not in their new home environments. Children who were enrolled in the study during the post-intervention period of follow-up were analyzed separately (children moving into study houses and children who reached the age of six months during follow-up).

Study group was left out of the exposure model because of its association with our exposure variables. This model was run using all five study groups and then again using the three R&M groups. Due to the consistency of the factor patterns noted above across campaigns, the interaction between factor1 and campaign and between factor2 and campaign were not found to be statistically significant and were dropped from later applications of the model. Other variables such as gender and mouthing variables were added to this basic model, but later dropped when found to be nonsignificant.

<u>Comparison Model</u>

$$ln(PbB)_{iklm} = \beta_0 + \beta_1 {*} age_{iklm} + \beta_2 {*} age^2_{iklm} + \beta_3 {*} summer_{iklm} + \beta_4 {*} male_{iklm} + \beta_5 {*} group_k + \beta_6 {*} campaign_l + b_i {*} house_i + b_{m(i)} {*} child_{m(i)} + \epsilon_{iklm} \quad \text{(Eq.4)}$$

(Refer to the exposure model above for an explanation of the notation used in Eq.4).

The comparison model was fit separately for children with blood lead concentrations <15µg/dL and ≥15µg/dL. According to CDC guidelines, children with blood lead concentrations ≥20µg/dL and children with persistent blood lead concentrations of 15-19 µg/dL should be referred for clinical evaluation, environmental investigation and remediation, and case management (CDC, 1997a) (Appendix C). Table 14 displays the numbers of children included in these models by initial blood lead concentration and by group. Although most children with baseline blood lead concentrations ≥15µg/dL were in R&M II and R&M III, the variances of baseline blood lead concentrations across the three groups were essentially the same. Descriptive statistics of baseline blood lead concentrations by group are shown in Appendix E.

The "group*campaign" interaction term and the gender and mouthing variables were not statistically significant. It should be noted that although the model includes a term for child within house to account for correlation between children in the same house, there were in actuality small numbers of households that had more than one child per house.

Table 14: Numbers of Children With Initial Blood Lead <15µg/dL and ≥15µg/dL

Study group	Initial Blood Lead <15 µg/dL n	Initial Blood Lead ≥15 µg/dL n
R&M I	25	8
R&M II	17	14
R&M III	18	17
Previously Abated	13	10
Modern Urban	19	0

Measurement Error

A number of researchers have raised the issue of measurement error in environmental variables. Measurement errors in the covariates or explanatory variables can affect the magnitude of the estimated regression coefficients in linear models. This effect usually results in attenuation and implies that observed effects are underestimated by an amount related to the magnitude of the errors in the covariates. The modeling approach used in our analysis uses factor analysis to derive environmental measures from the basic environmental samples. The factors (latent variables) are assumed random in this approach, similar to the representation in a measurement error model. The use of latent variables implicit in the measurement error models is thus present in our approach where these variables are explicitly treated as part of the model. While measurement error is present in the environmental samples, we believe that the approach using factor analysis adequately accounts for the presence of measurement error (Fuller, 1987). Furthermore, the current lack of off-the-shelf software to address measurement error makes it difficult to replicate such analyses.

7.0 RESULTS

This section is divided into three parts. The first provides descriptive statistics on environmental data and blood data from the first two years of follow-up, including a series of side-by-side boxplot figures with median traces to graphically display trends across time. The second presents descriptive statistics on data derived from the 24-month campaign and an analysis of the correlations between children's blood lead concentrations and their dust lead exposure (Section 7.2). These descriptive statistics do not take into account season or any other potential covariates. Part three presents findings of the longitudinal data analysis and includes a summary of the statistical significance of trends in dust lead and blood lead over time within and across groups (Section 7.3), when controlling for season and other covariates and with house as a random effect.

7.1 Descriptive Statistics For The First Two Years Of Follow-Up

Side-by-Side Boxplots With Dust Data

Figures 1-12 show the distributions of dust lead loadings, dust lead concentrations, and dust loadings by study group across campaigns for each of four main surface types. The boxplots are displayed on the $\log_{10}$ scale, due to the wide ranges of dust values (see Section 6.3 for an explanation of the components of a boxplot). Lead loadings below 1 $\mu g/ft^2$ are displayed as 1 (or zero on the log scale). These figures reveal the following trends:

- Median traces for dust lead loadings across surface types show a pattern of maximally reduced levels at post-intervention. This pattern is most pronounced for R&M III houses, intermediate for R&M II houses, and smallest for R&M I houses. At two months, lead loadings tended to increase over post-intervention levels, but they were below pre-intervention levels, except for floors and entryways of R&M I and R&M II houses in which lead loadings did not increase at two months. Between two months and 24-months, median lead loadings in the three groups of R&M houses were relatively stable and remained below pre-intervention levels (Figures 1-4).

- Median traces for dust lead concentrations reveal a downward trend at post-intervention and at two months across sample types for R&M II and R&M III houses, but not for R&M I houses. The reduction in lead concentrations was most pronounced in R&M III houses. Between two months and 24 months, the median lead concentrations remained relatively stable across the three groups of R&M houses (Figures 5-8).

- The median traces for dust loadings show a similar pattern as the lead loadings where reductions at post-intervention were greatest in R&M III houses, intermediate in R&M II houses, and smallest in R&M I houses. At two months, median dust loadings tended to reaccumulate over the post-intervention loadings, but they remained below pre-intervention levels. Between two months and 24-months, median dust loadings in the three groups of R&M houses were relatively stable and remained below pre-intervention levels (Figures 9-12).

- The modern urban and previously abated control houses show a pattern of relatively stable median lead loadings, lead concentrations, and dust loadings. There is a slight downward trend in lead loadings and dust loadings during the two years of follow-up (Figures 1-12).

Side-By-Side Boxplots Of Blood Lead Concentrations

Figure 13 provides boxplot displays of unadjusted blood lead concentrations by study group for children with initial blood lead concentrations <15 µg/dL. The child treated with a blood lead concentration of 53 µg/dL in the previously abated group at 12 months does not appear on the figure. The median traces for each of the three R&M groups show slight downward tends in children's blood lead concentrations during the two years of follow-up, unadjusted for covariates. Unadjusted median blood lead concentrations in children in the previously abated houses and the modern urban houses, increased slightly during the first year of follow-up and declined during the second year.

"Hair Clip" Line Plots With Blood Lead Concentrations For Individuals

Figures 14-18 are "hair clip" line plots of blood lead concentrations for individual children in each of the five study groups, excluding children who moved into study houses during follow-up and those who reached the age of six months during follow-up. These figures display each of the original study children's unadjusted blood lead concentrations at baseline and during the two years of follow-up. The "hair clip" plots link specific blood lead values to specific collection dates and display seasonal variations in blood lead concentrations. Most of the children with baseline blood lead concentrations ≥20 µg/dL were in the R&M II and R&M III study groups; only one was in the R&M I group. As seen in these plots, children with baseline blood lead concentrations ≥15-20 µg/dL experienced reductions in their blood lead concentrations over time, while those with baseline blood lead concentration <15 µg/dL tended to remain <15 µg/dL during the two years of follow-up.

Figure 19 is a separate "hair clip" plot of blood lead concentrations for individual children who reached the age of six months during follow-up by study group. These children were first tested when they reached six months of age. As shown in the figure, their blood lead concentrations tended to increase over time; however, for most children in the three R&M groups and the previously abated group blood lead concentrations remained 10 µg/dL. Blood lead concentrations of children in the modern urban control houses who reached the age of six months during follow-up remained 5 µg/dL over time. A child born into the previously abated group had a baseline blood lead concentration of 35 µg/dL and experienced a decline in blood lead concentration to 15 µg/dL at the end of one year of follow-up. The small numbers of children precluded statistical analysis of group differences.

Figure 1 Dust Lead Loadings (PbD in ug/sq.ft.) Across Campaigns For Floor Surfaces

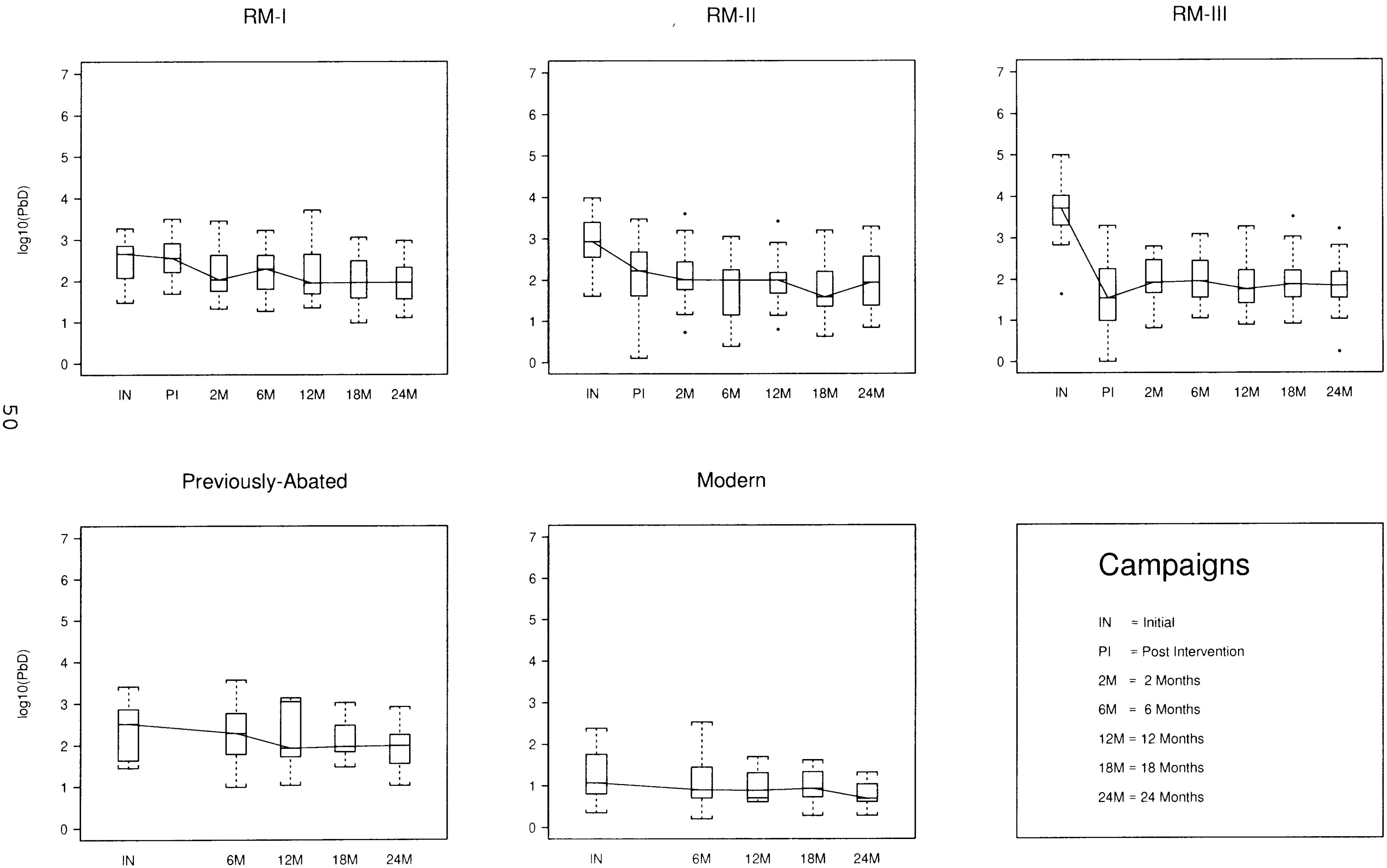


Figure 2 Dust Lead Loadings (PbD in ug/sq.ft.) Across Campaigns For Window Sill Surfaces

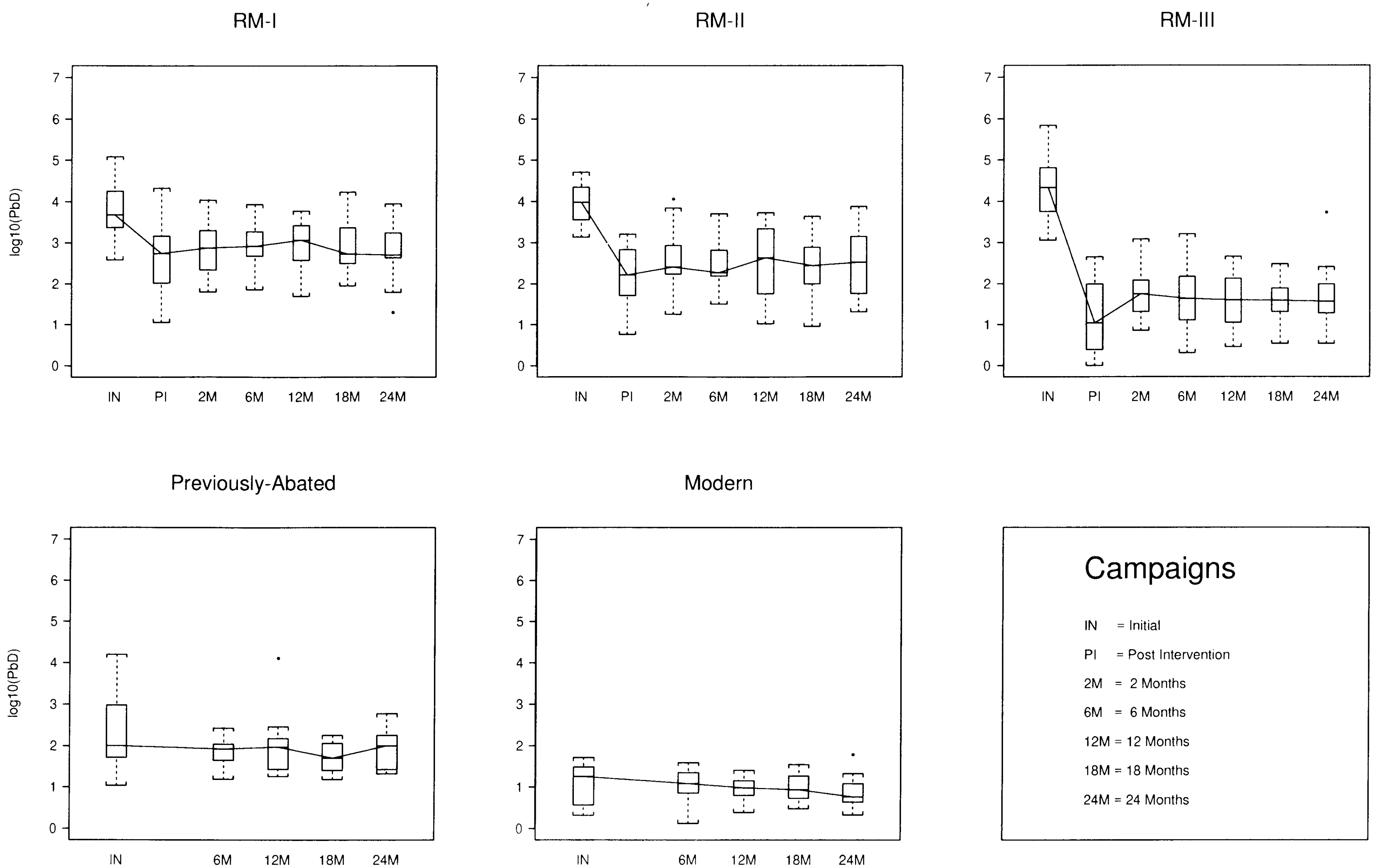


Figure 3 Dust Lead Loadings (PbD in ug/sq.ft.) Across Campaigns For Window Well Surfaces

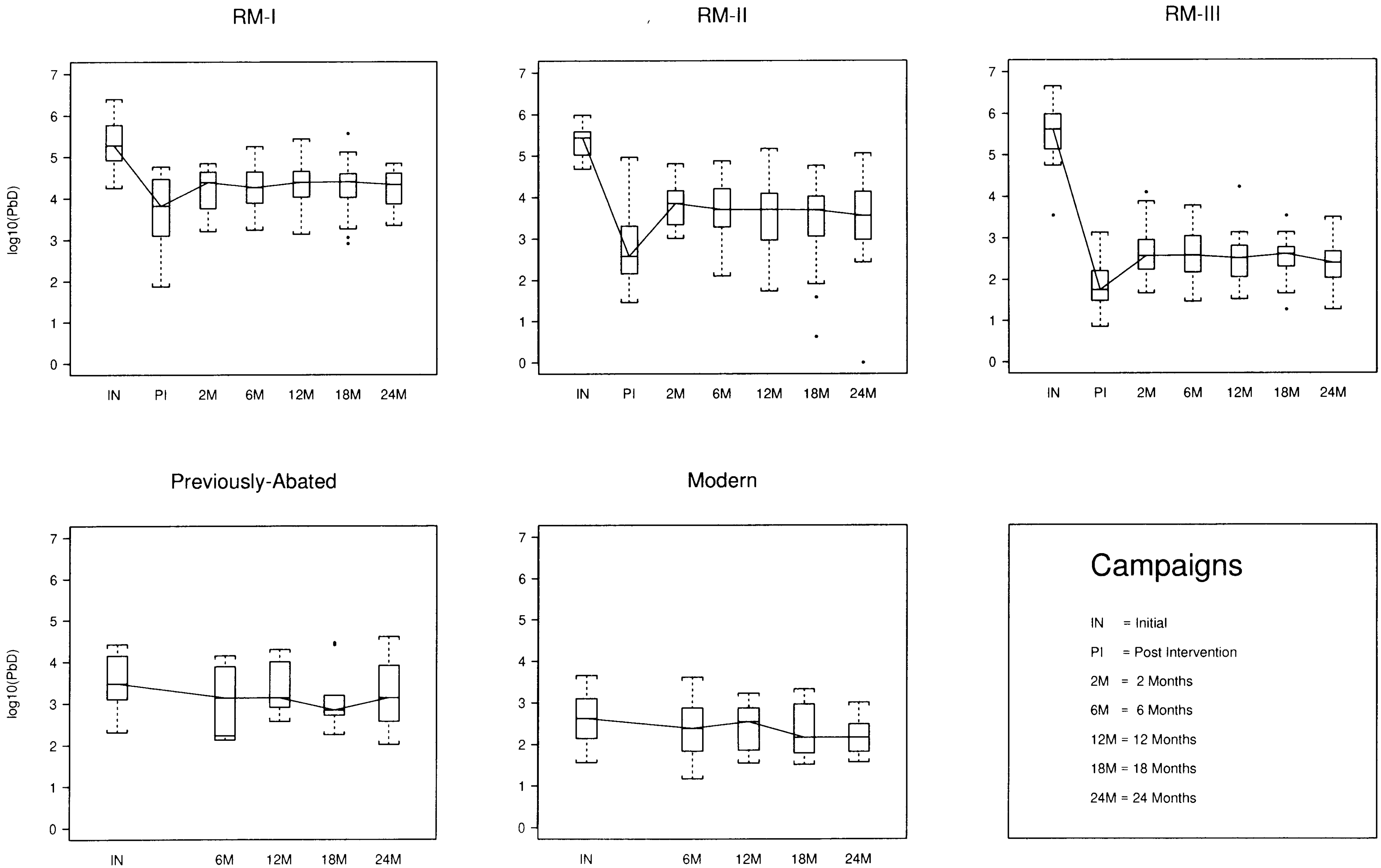


Figure 4 Dust Lead Loadings (PbD in ug/sq.ft.) Across Campaigns For Int. Entryway Surfaces

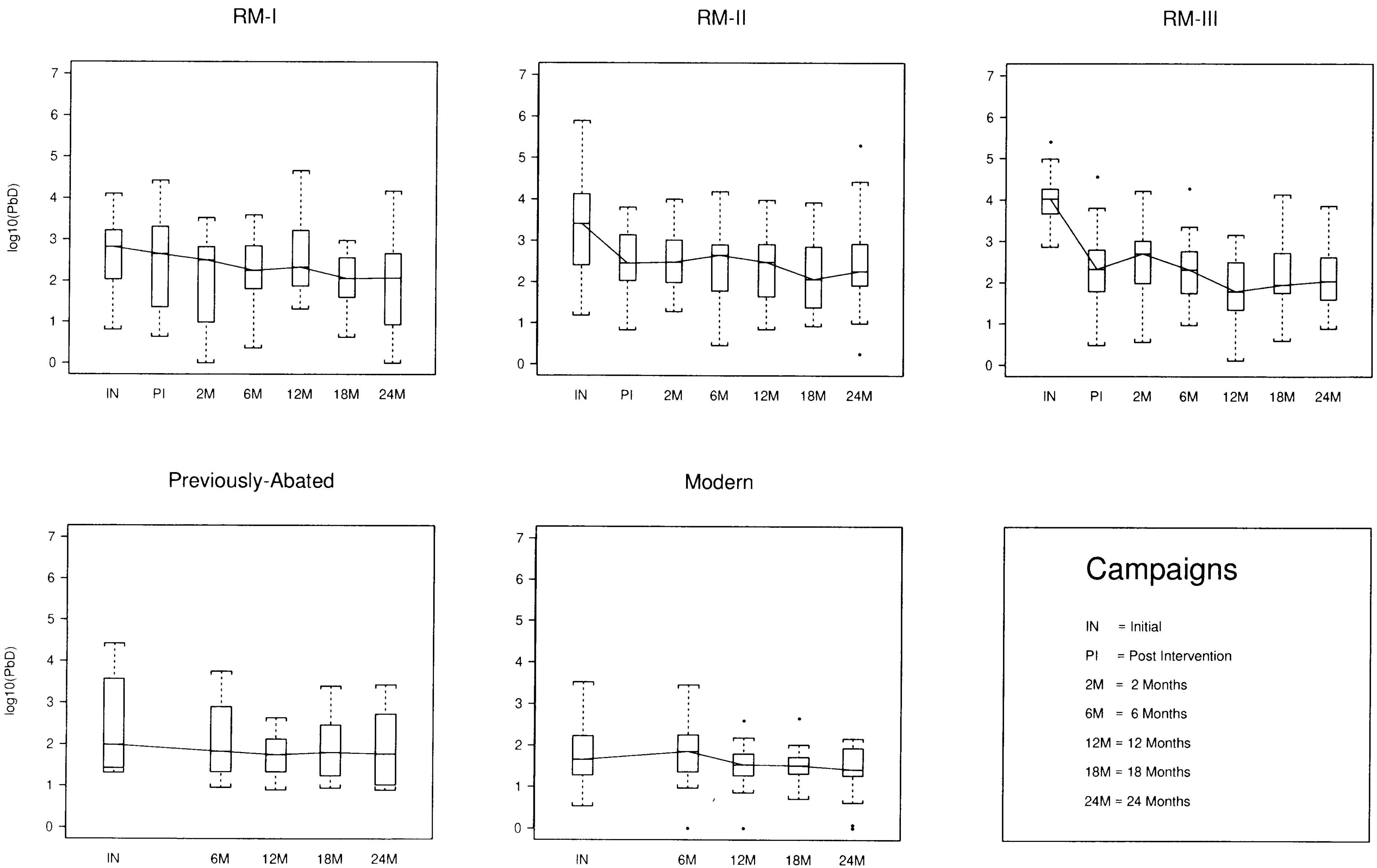


Figure 5 Dust Lead Concentration (PbD-C in ug/g) Across Campaigns For Floor Surfaces

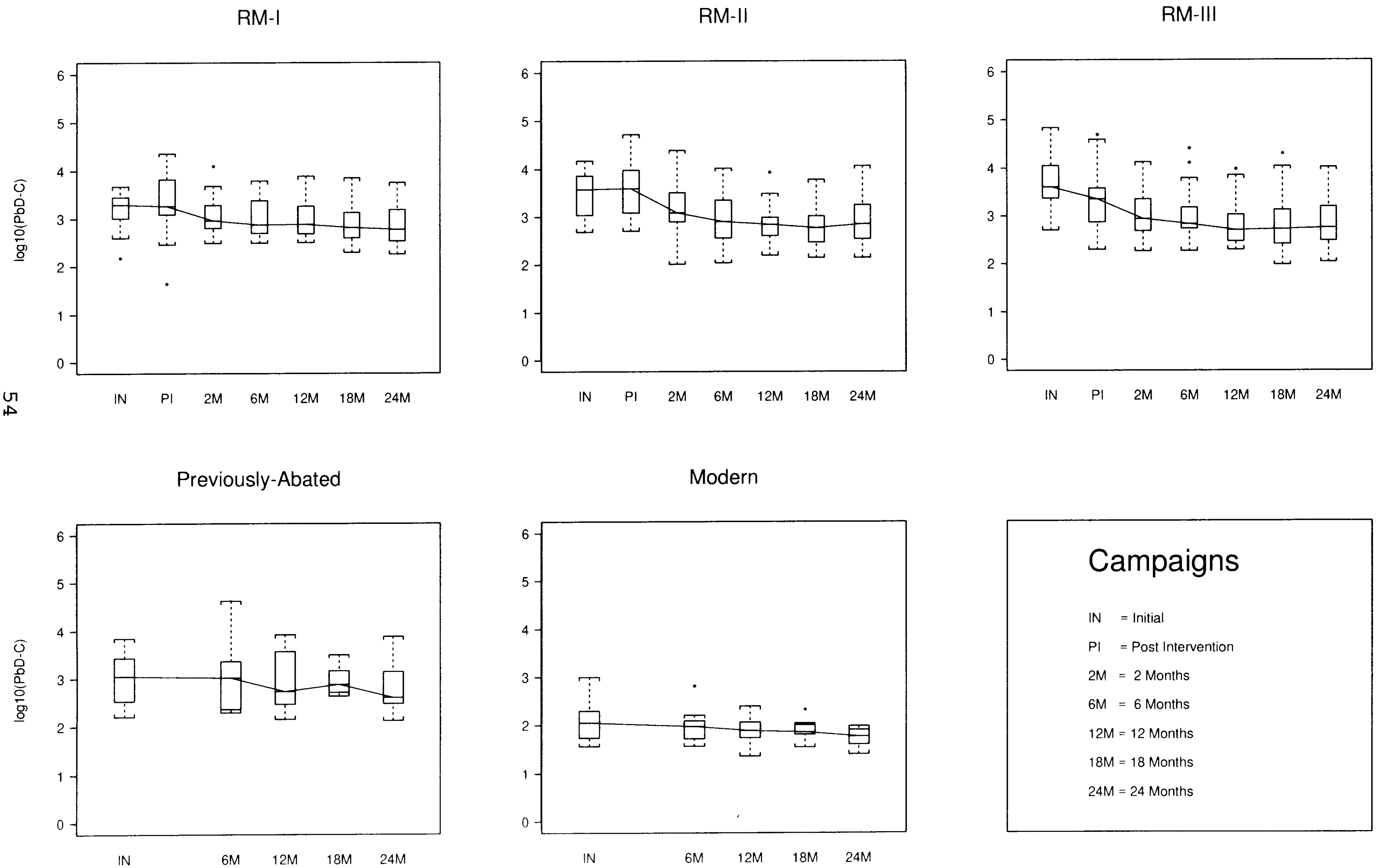


Figure 6 Dust Lead Concentration (PbD-C in ug/g) Across Campaigns For Window Sill Surfaces

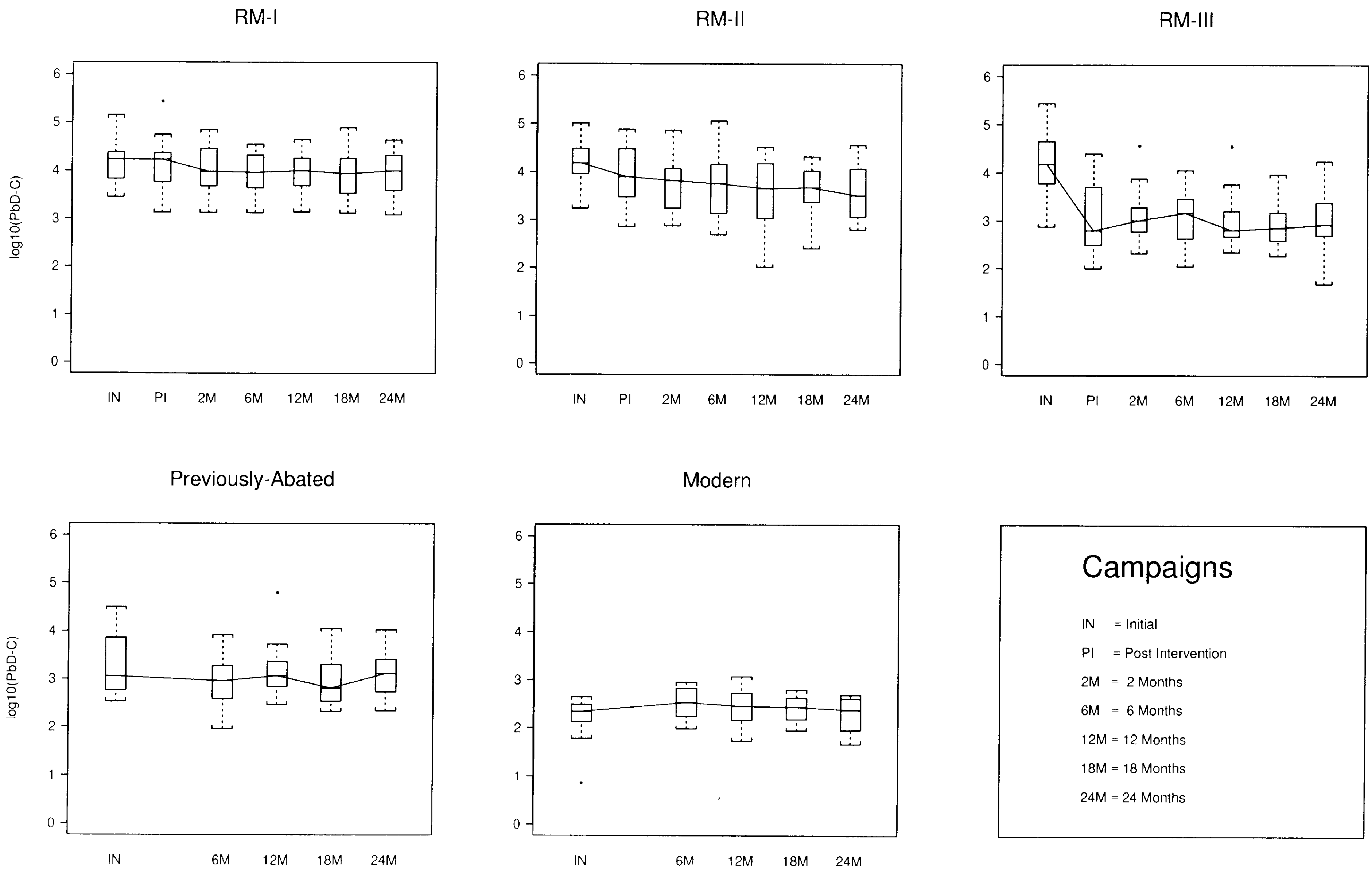


Figure 7 Dust Lead Concentration (PbD-C in ug/g) Across Campaigns For Window Well Surfaces

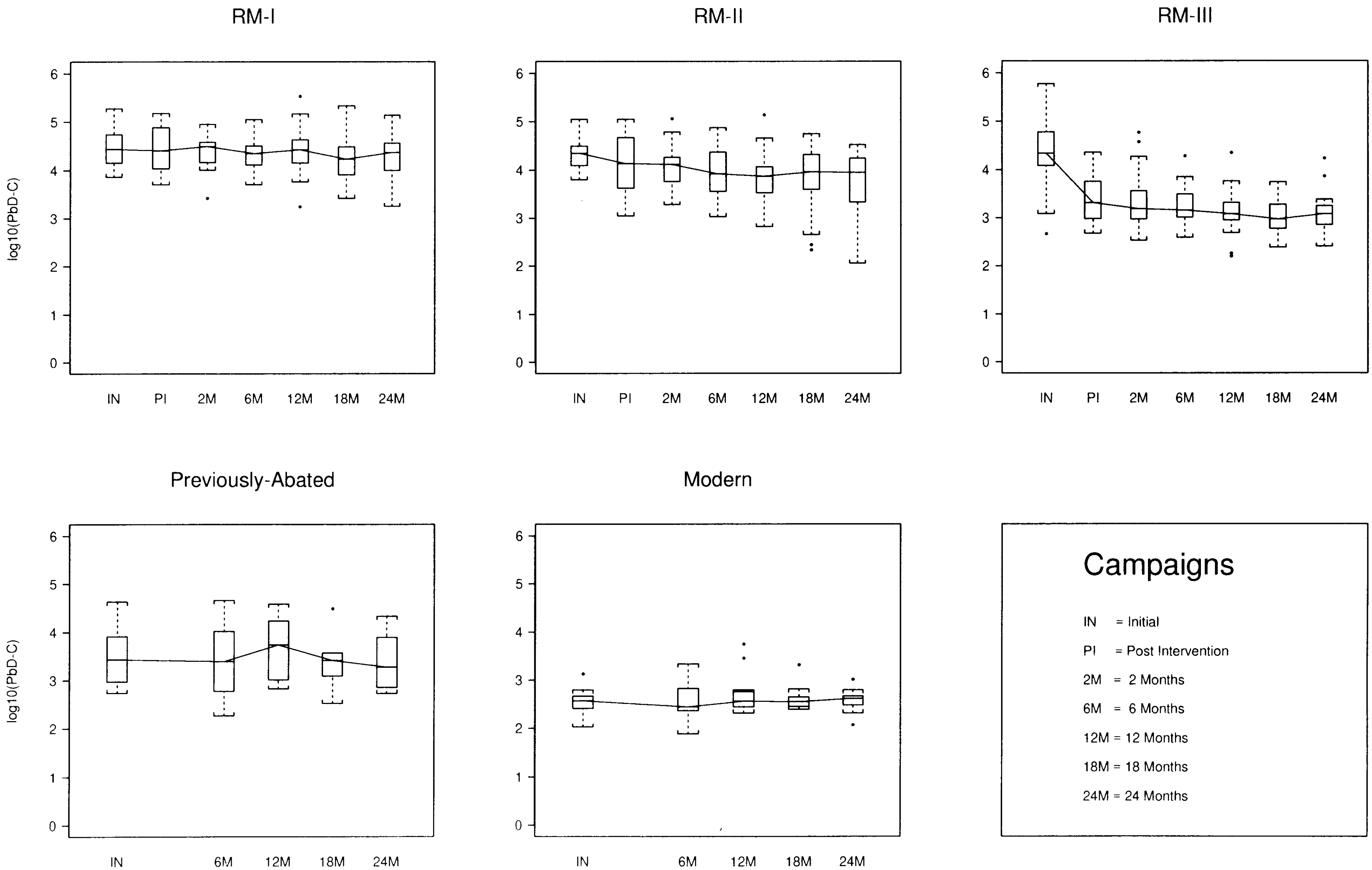


Figure 8 Dust Lead Concentration (PbD-C in ug/g) Across Campaigns For Int. Entryway Surfaces

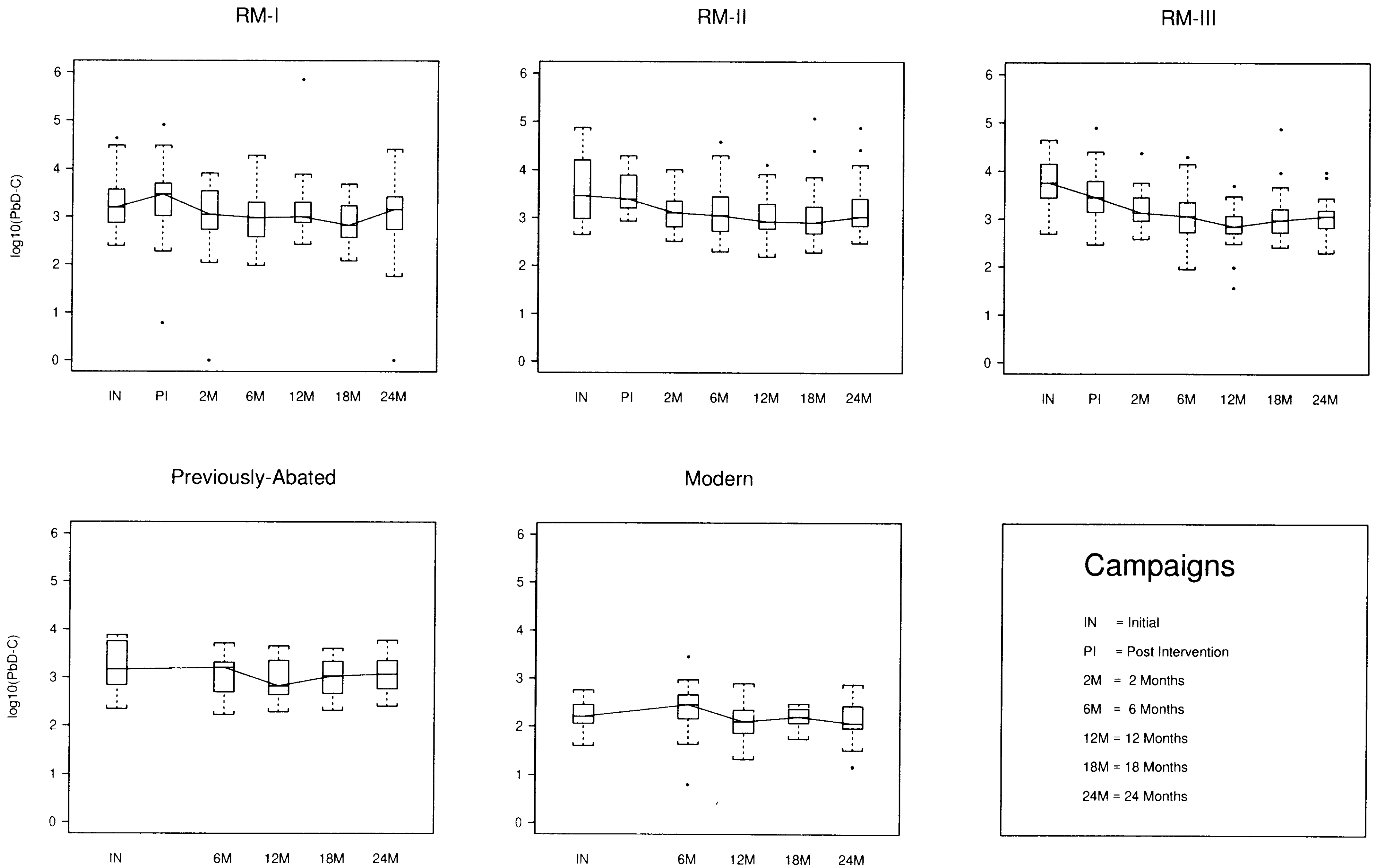


Figure 9 Dust Loadings (Dust in mg/sq.ft.) Across Campaigns For Floor Surfaces

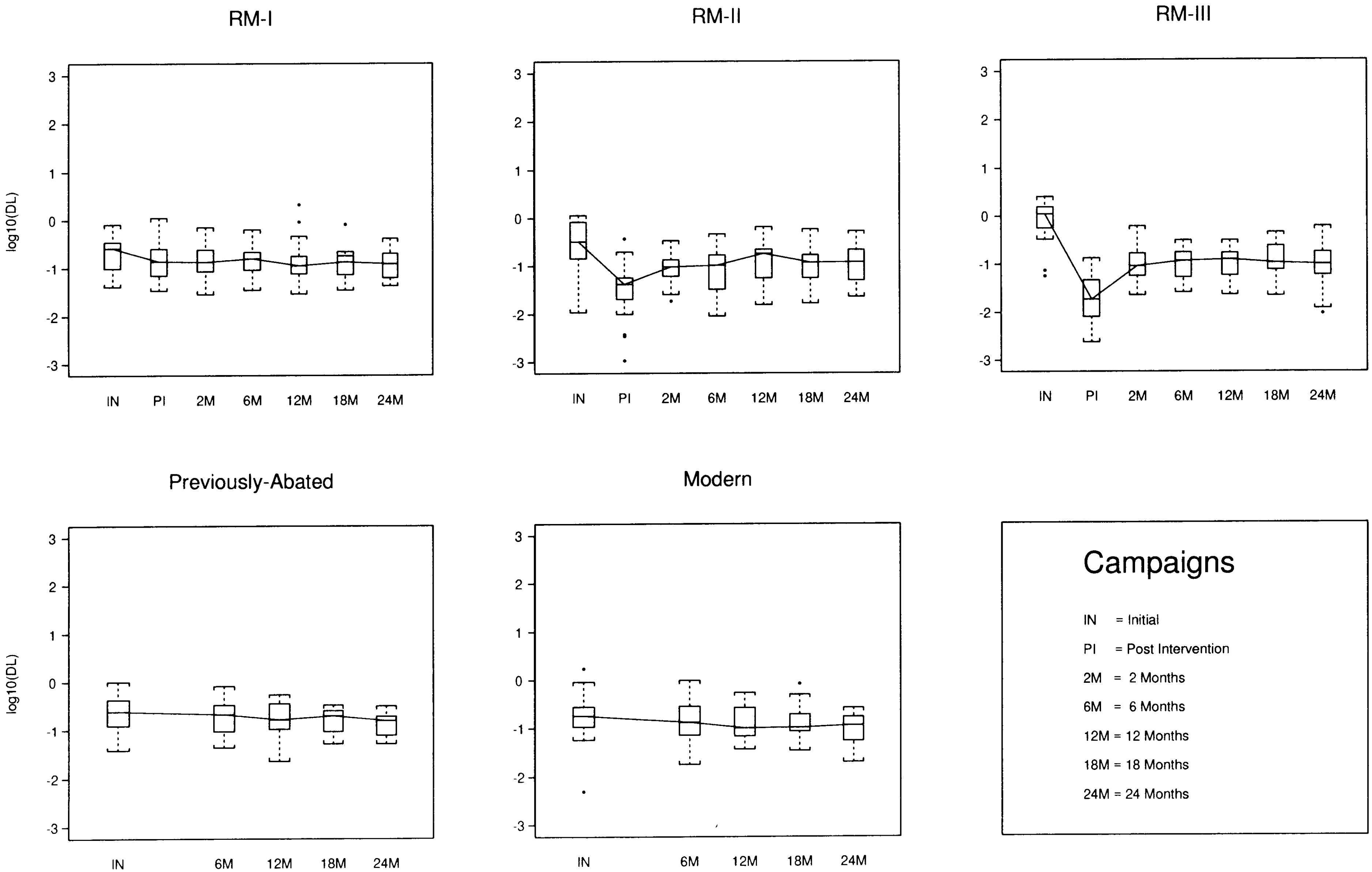


Figure 10 Dust Loadings (Dust in mg/sq.ft.) Across Campaigns For Window Sill Surfaces

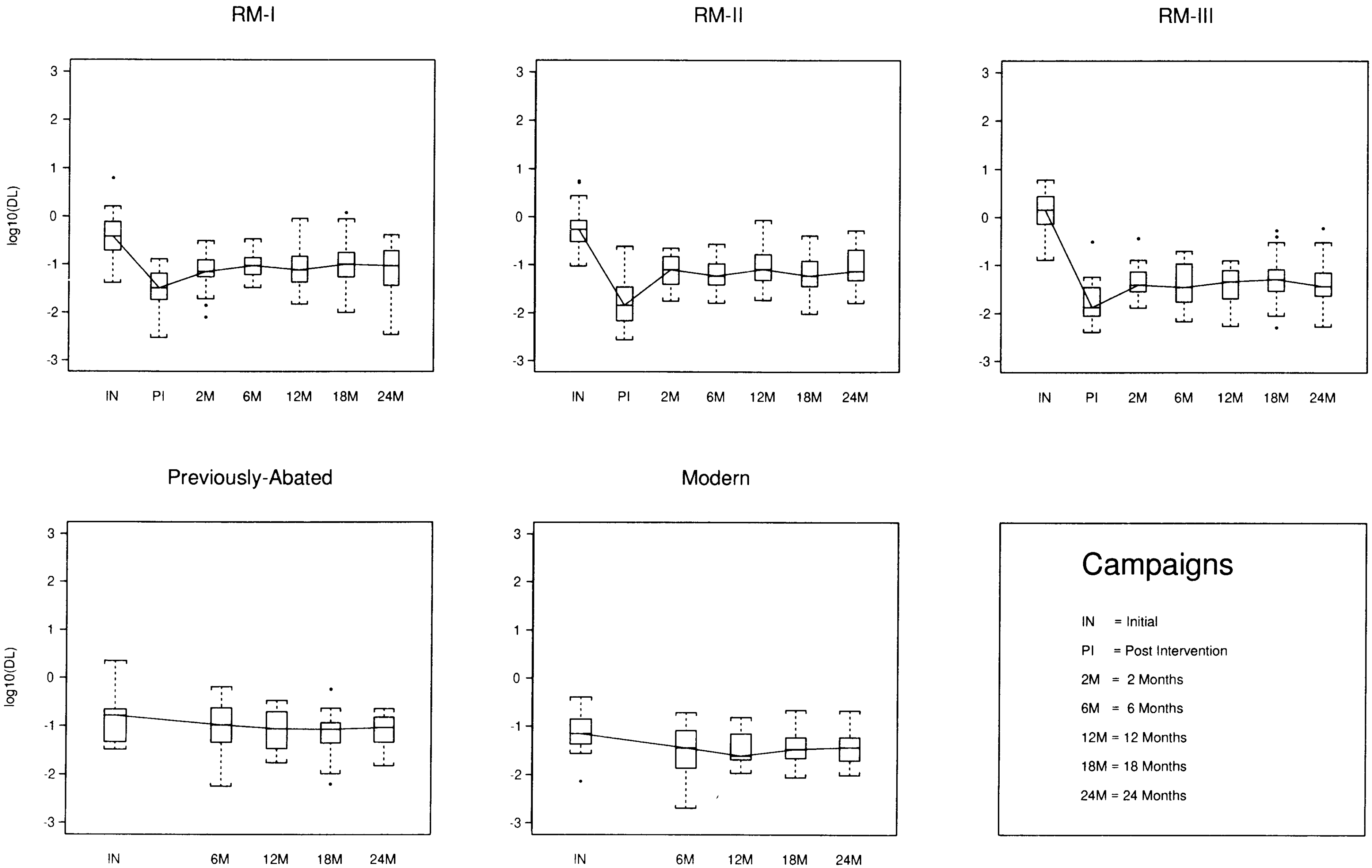


Figure 11 Dust Loadings (Dust in mg/sq.ft.) Across Campaigns For Window Well Surfaces

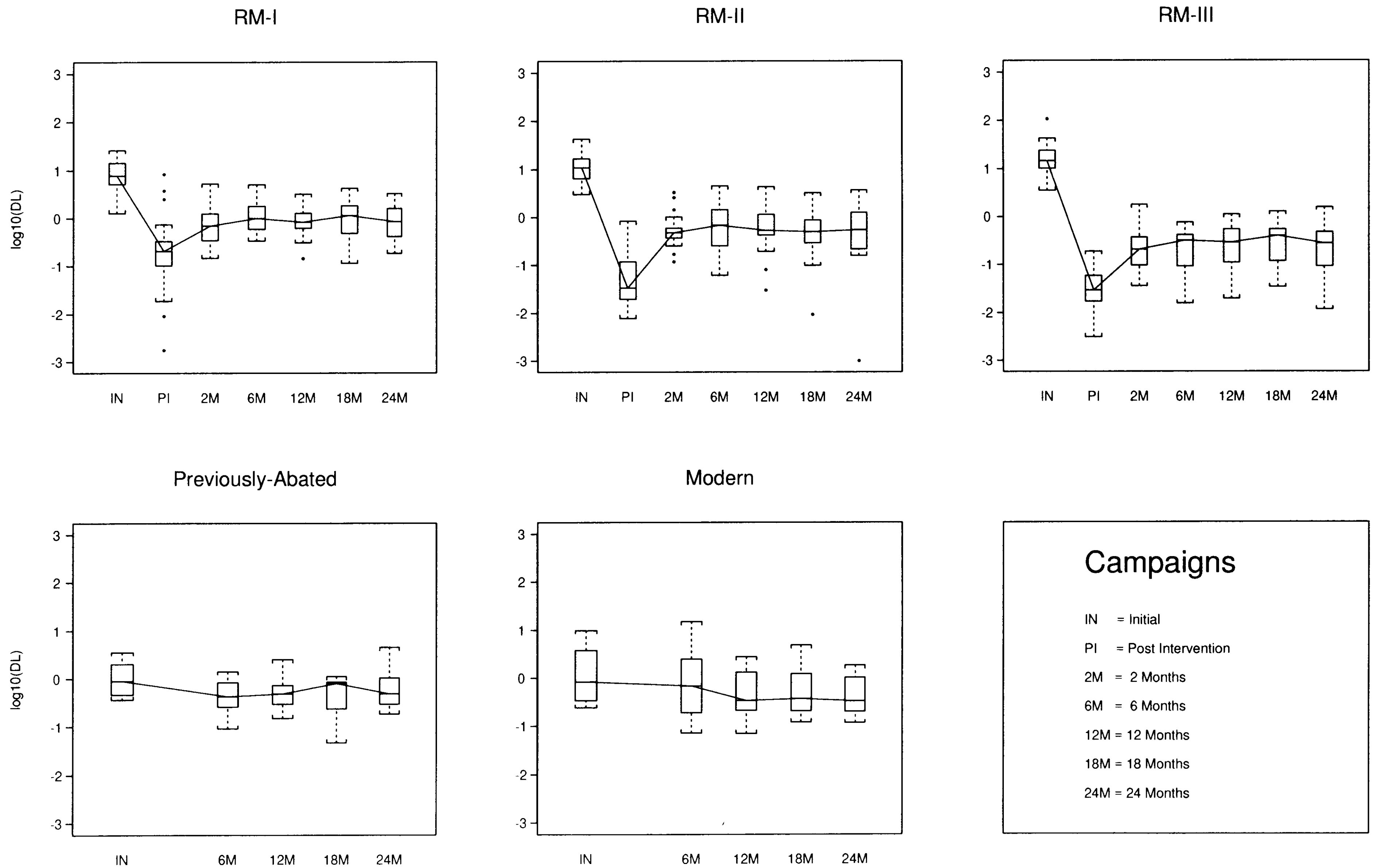


Figure 12 Dust Loadings (Dust in mg/sq.ft.) Across Campaigns For Int. Entryway Surfaces

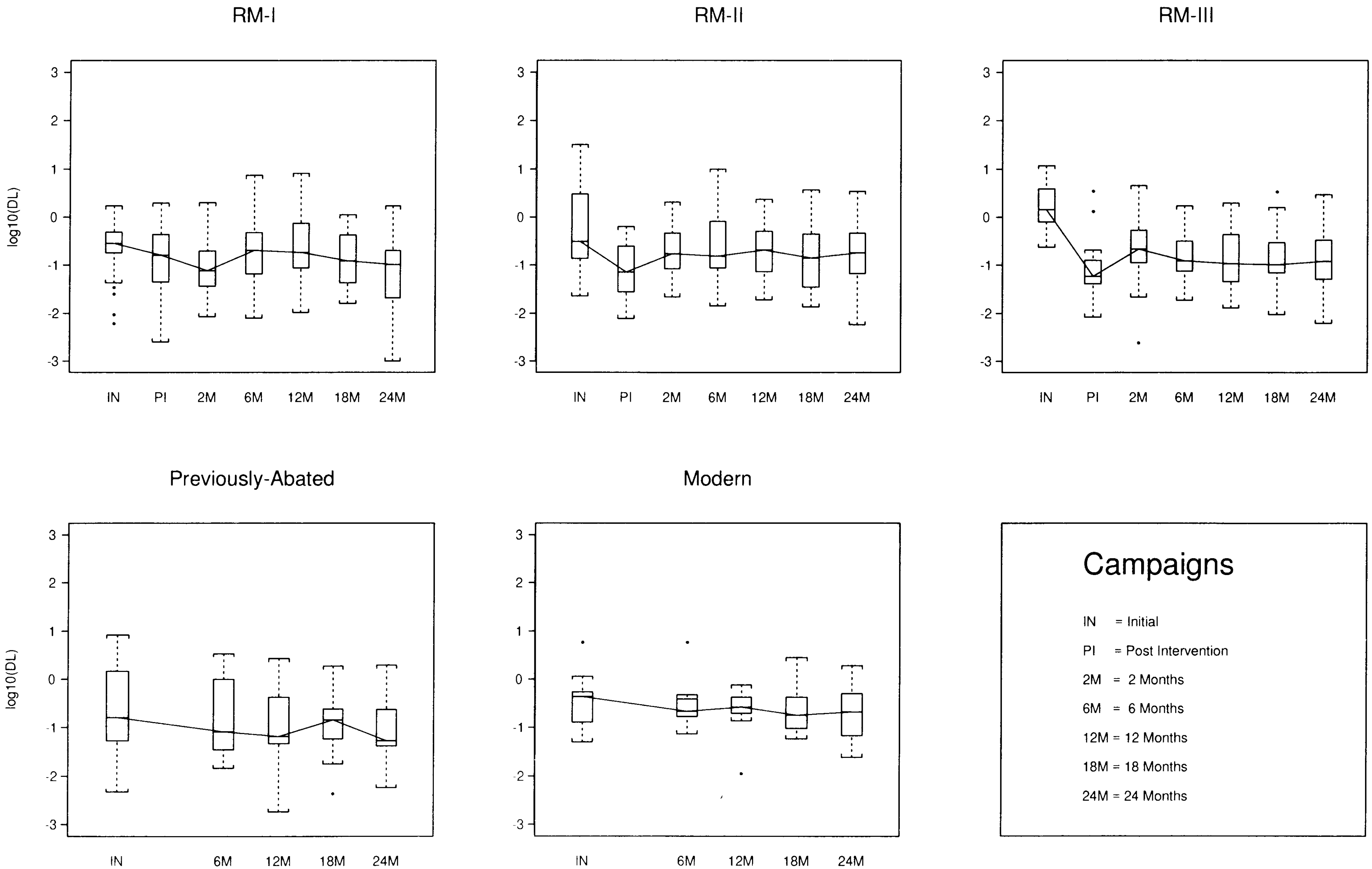
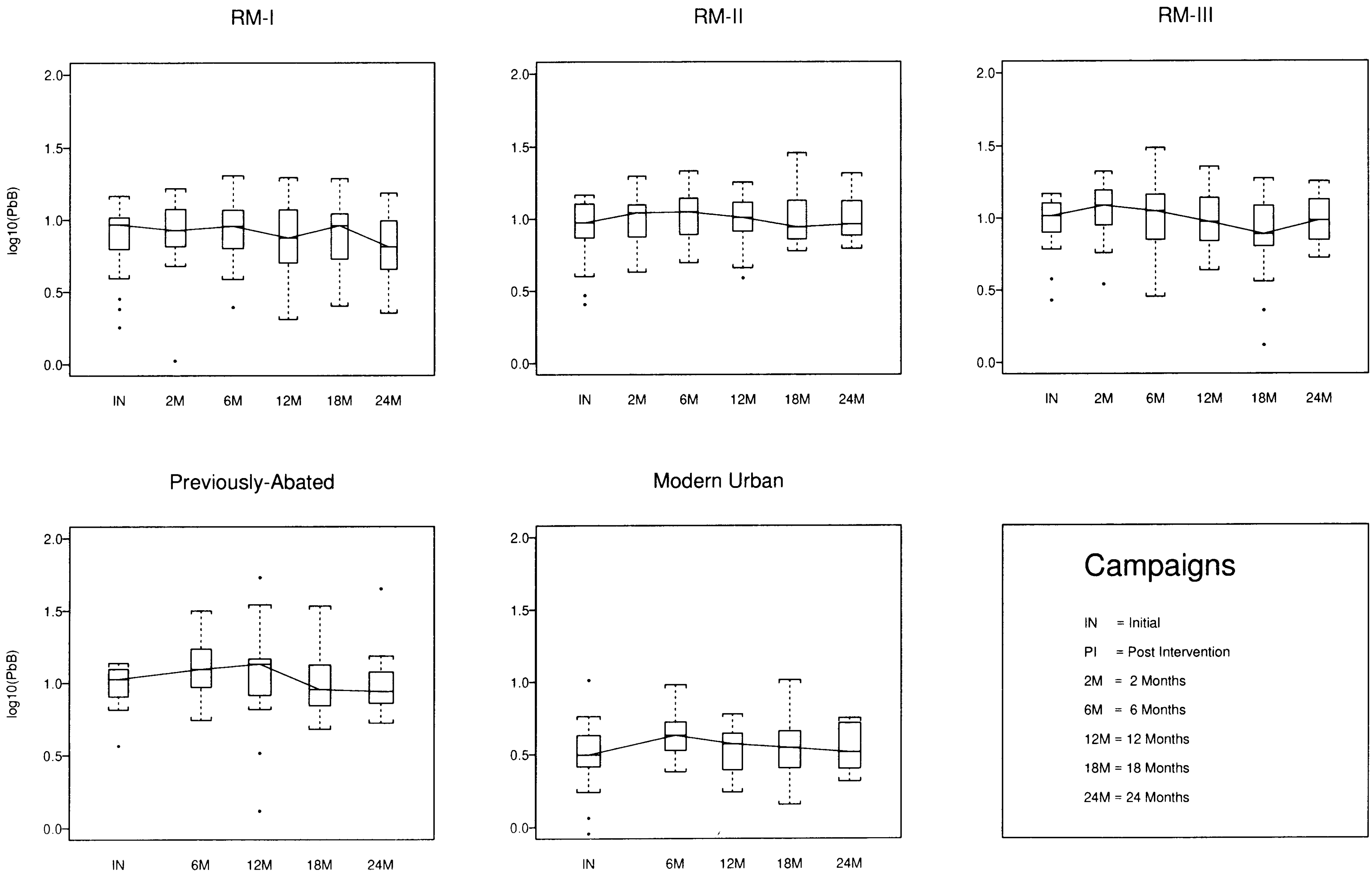


Figure 13 Blood Lead Concentrations (PbB in ug/dL) for Children with Initial PbB < 15 ug/dL



For PDF imaging reasons, Figures 14 through 19 may not be an exact replica of what appears in the published paper version. Viewers who want an exact replica should obtain a paper copy of the report by calling 1-800-424-LEAD.

Figure 14: **Repair & Maintenance Study - 24 Month Report**

Blood Lead Concentrations for Children Enrolled at the Initial Campaign

R&M I Houses

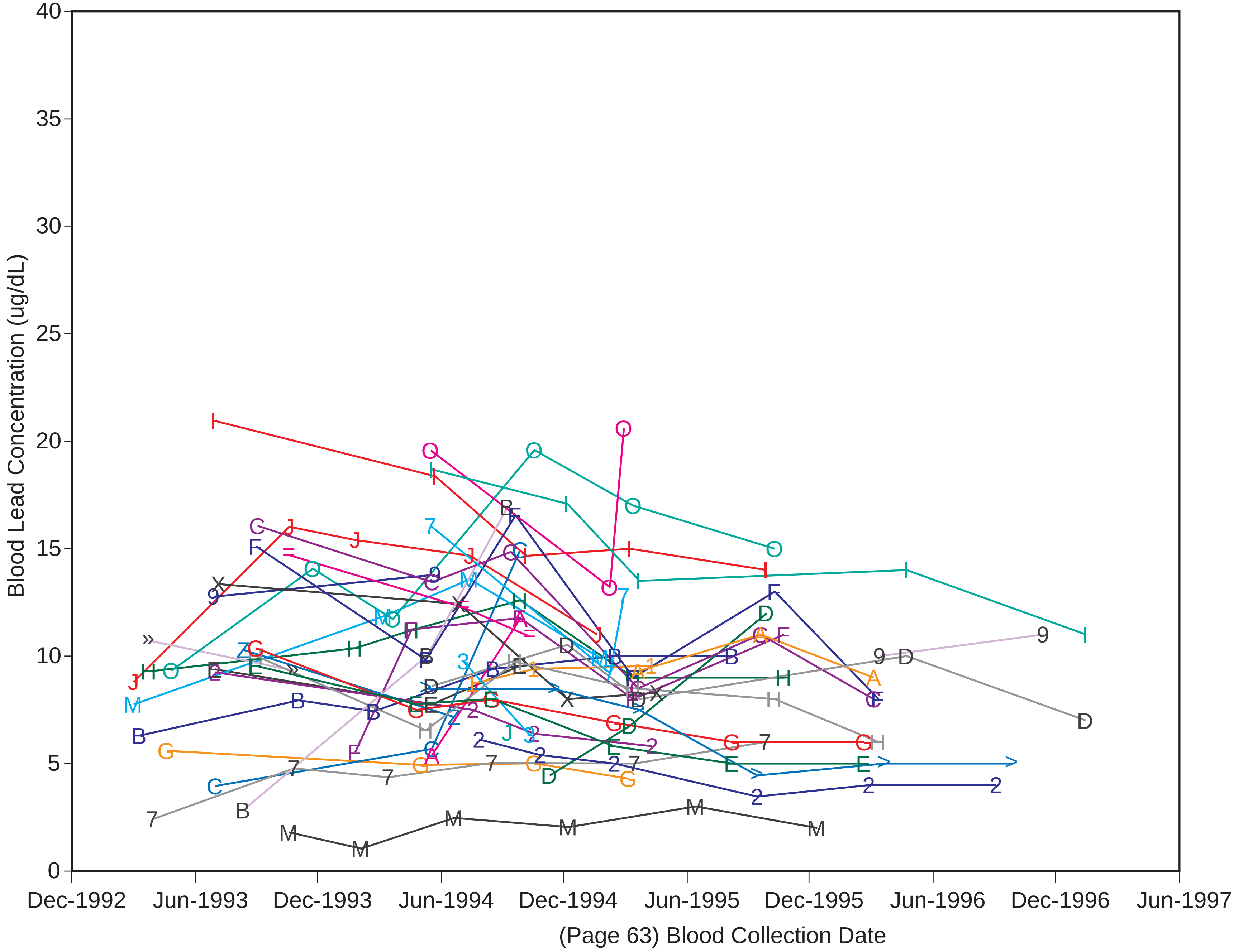


Figure 15: Repair and Maintenance Study - 24 Month Report
Blood Lead Concentrations for Children Enrolled at the Initial Campaign
R&M II Houses

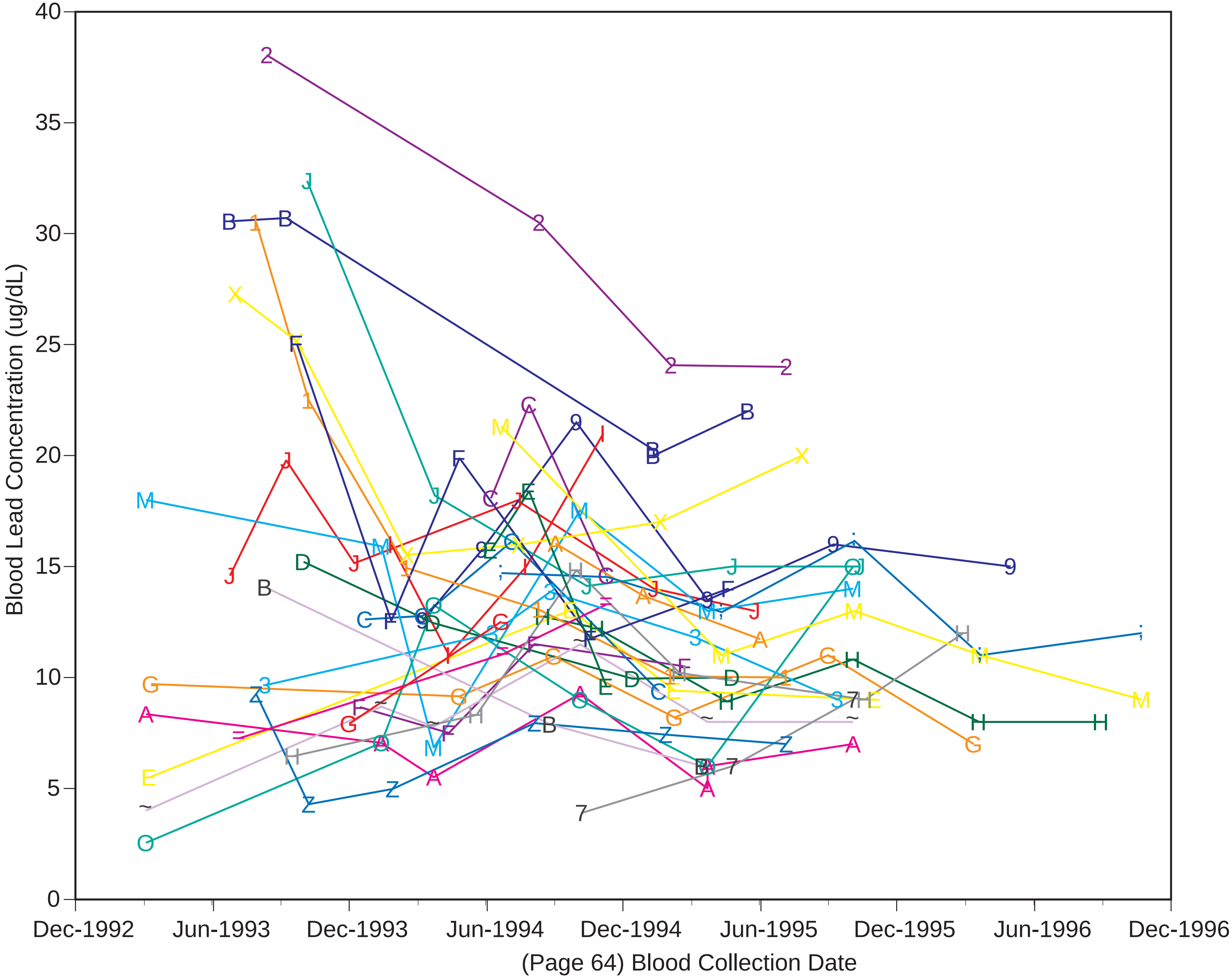


Figure 16: Repair & MaintenanceStudy - 24 Month Report
Blood Lead Concentrations for Children Enrolled at the Initial Campaign
R&M III Houses

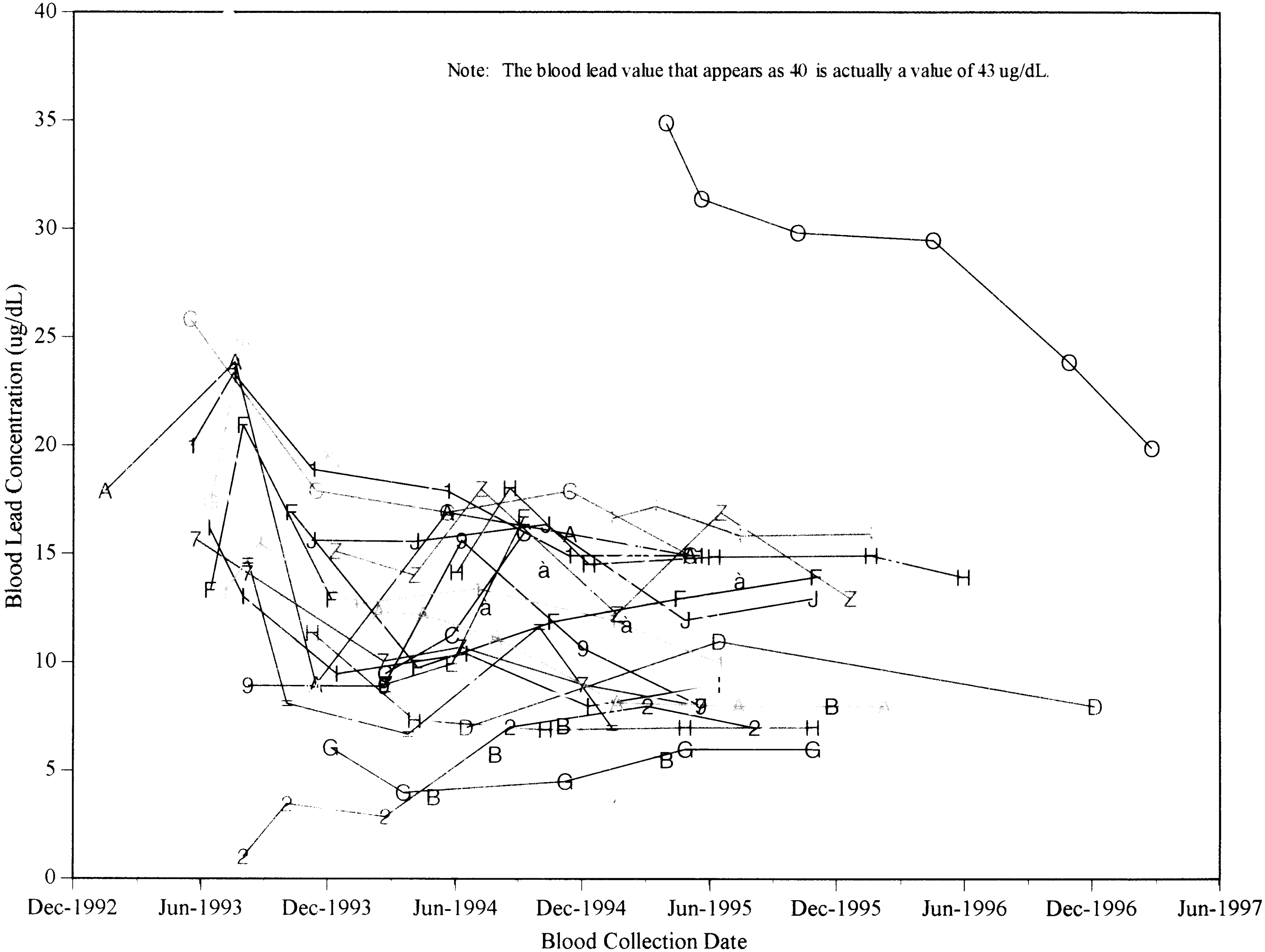


Figure 17: **Repair & Maintenance Study - 24 Month Report**
Children's Blood Lead Levels Across Time - Modern Urban Houses

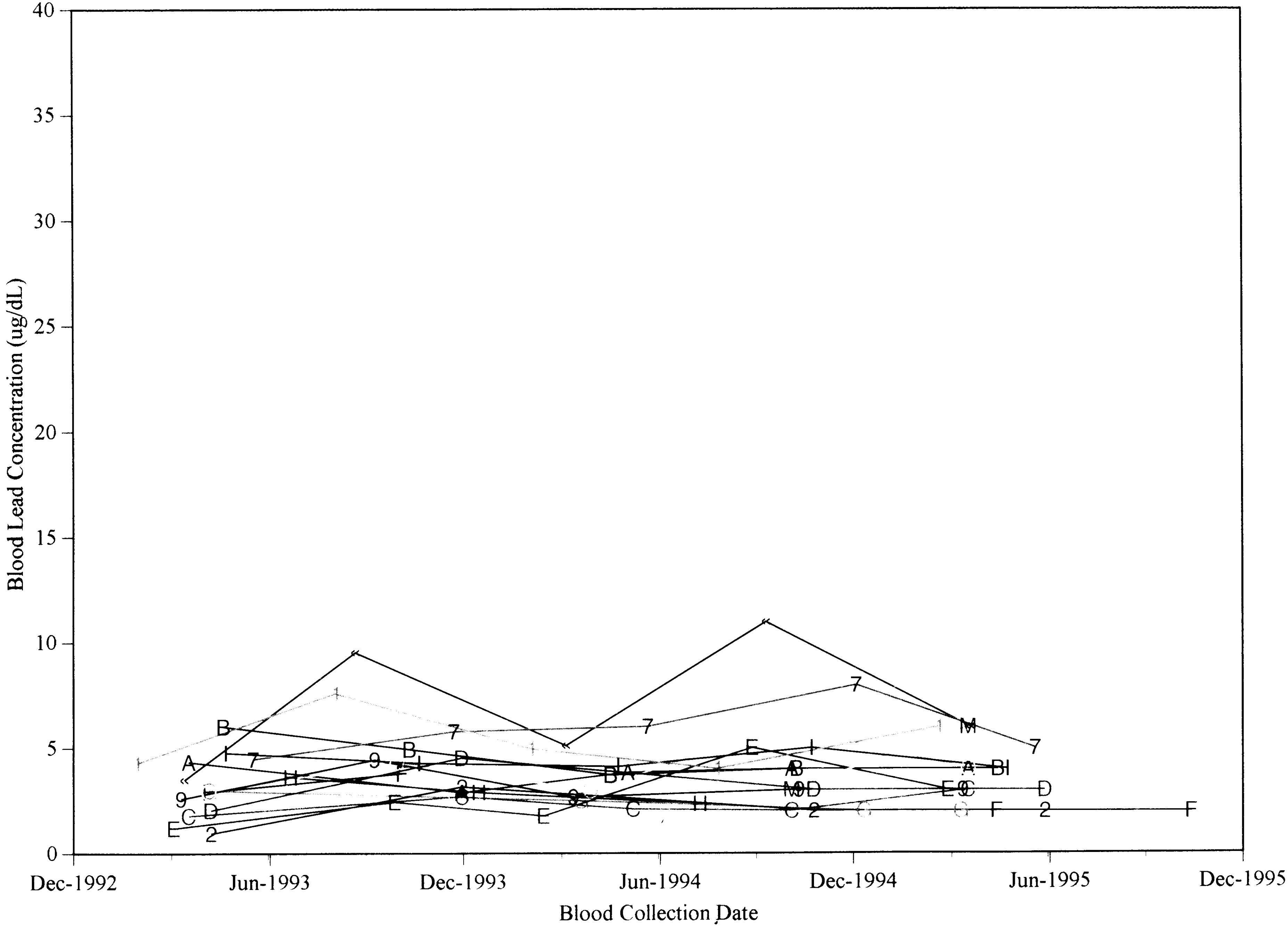


Figure 18: **Repair & Maintenance Study - 24 Month Report**
Blood Lead Concentrations for Children Enrolled at the Initial Campaign
Previously Abated Houses

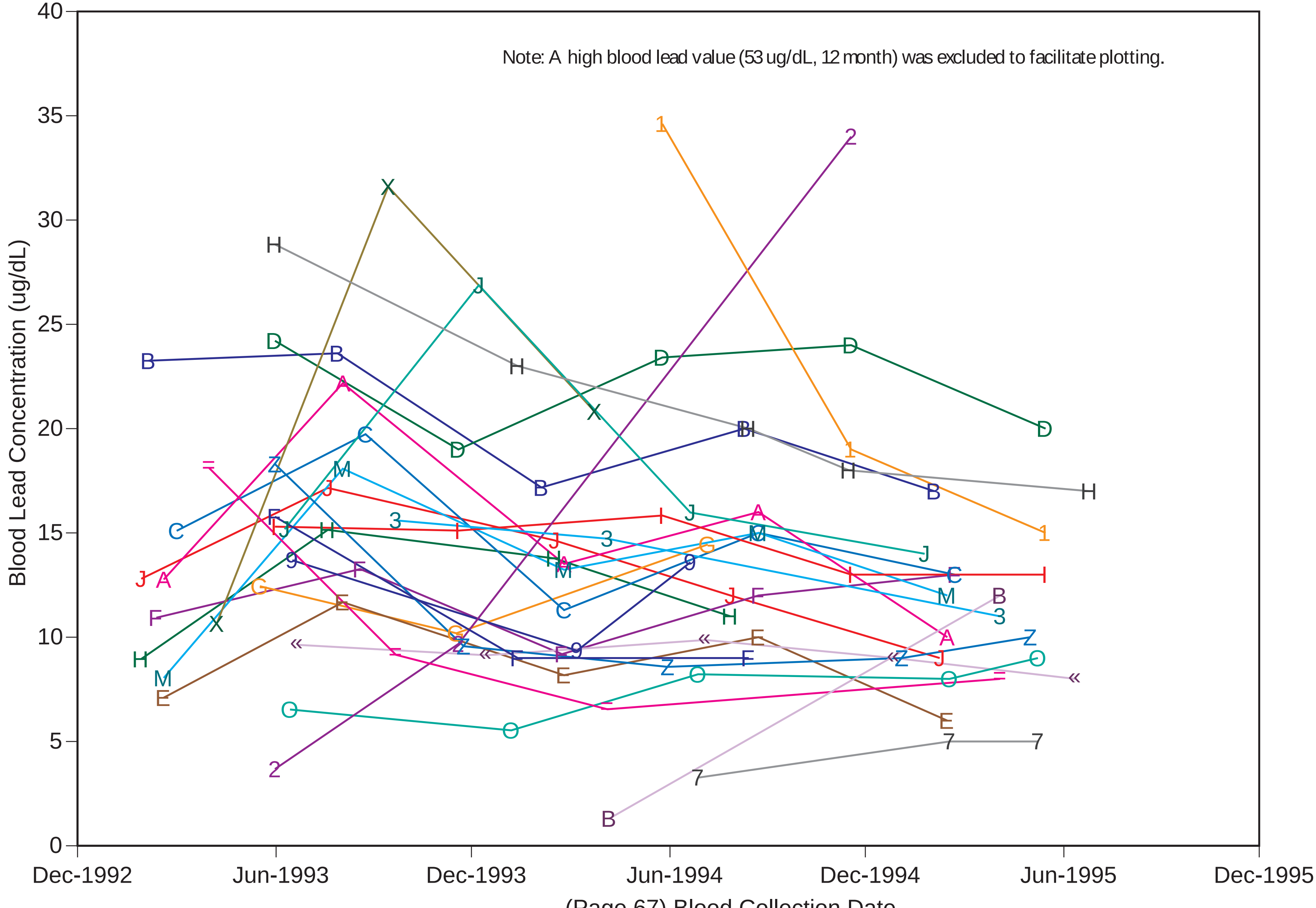
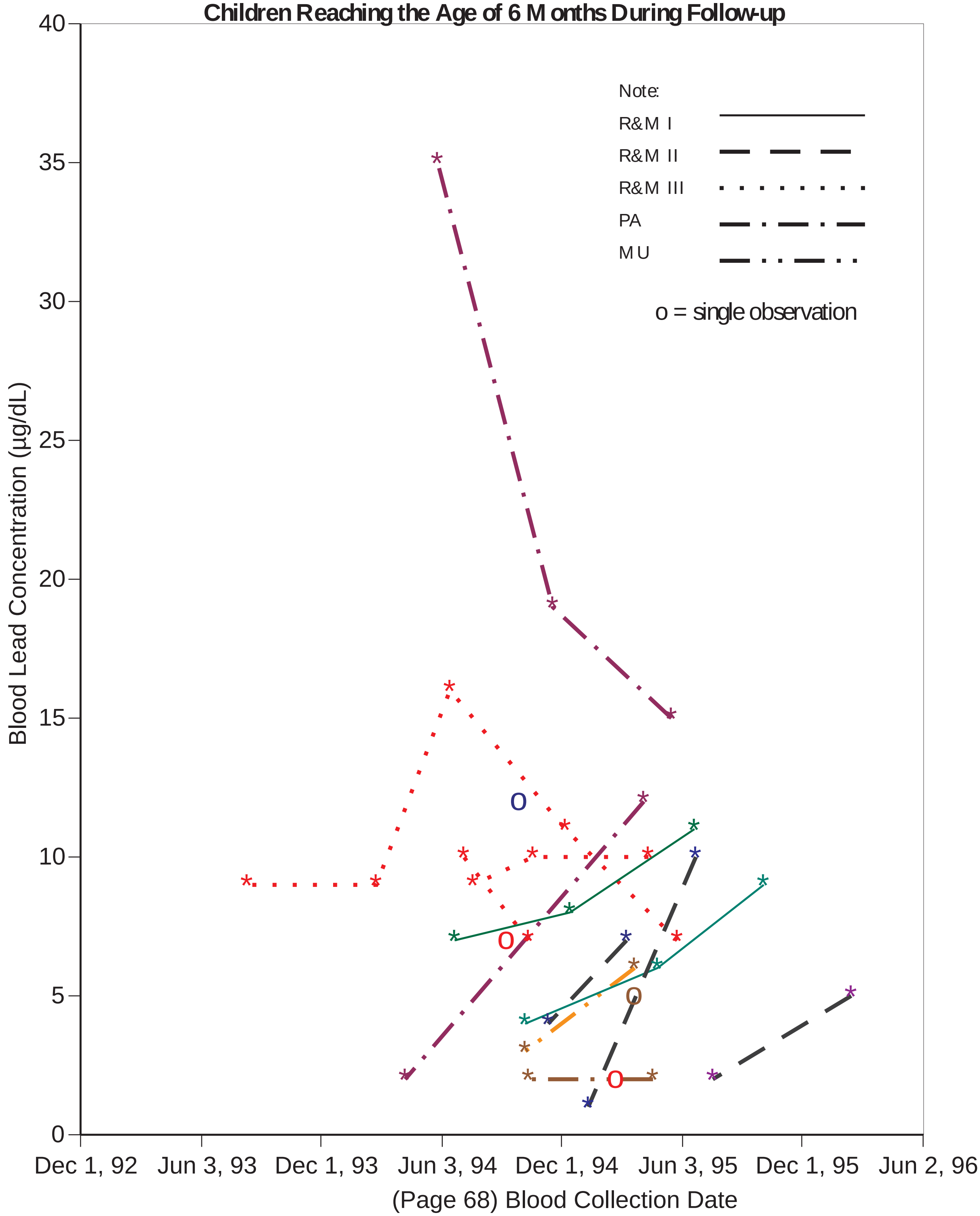


Figure 19: Repair & Maintenance Study - 24 Month Report
Blood Lead Levels Across Time
Children Reaching the Age of 6 Months During Follow-up



For PDF imaging reasons, Figures 14 through 19 may not be an exact replica of what appears in the published paper version. Viewers who want an exact replica should obtain a paper copy of the report by calling 1-800-424-LEAD.

7.2 Descriptive Statistics At The 24-Month Campaign

Blood Lead Concentrations At 24 Months

Table 15 provides descriptive statistics for unadjusted blood lead concentrations at 24 months by study group for children with initial blood lead concentrations <15 µg/dL. Children whose blood lead concentrations were not available at the initial campaign (*e.g.*, move-ins and children who reached the age of six months during follow-up) are excluded from these statistics. Adjusted blood lead concentrations are provided in Section 7.3. The median age of these children at 24 months ranged from 3.9 to 5.4 years across the five groups.

Dust Lead Loadings, Lead Concentrations And Dust Loadings At The 24-Month Campaign

Descriptive statistics for settled dust at the 24-month campaign are graphically displayed as bar graphs showing geometric mean dust lead loadings (µg/ft^2), dust lead concentrations (µg/g), and dust loadings (mg/ft^2) by group and by surface type in Figures 20 to 22. Tables B-1 to B-3 display descriptive statistics (geometric mean, n, minimum, maximum, standard deviation) for lead loadings, lead concentrations and dust loadings by group and by surface type (Appendix B). Figures 20-22 show that air ducts and window wells had the highest lead loadings and dust loadings among the various surfaces types across study groups. Lead concentrations tended to be highest for window wells and window sills. The following paragraphs provide selected detailed information provided in Tables B-1 to B-3 in Appendix B.

Geometric mean lead loadings were 460 µg/ft^2 across groups and surface types at the 24-month campaign, except for air ducts in all groups and window wells in R&M I, R&M II and previously abated houses. Geometric mean air duct lead loadings ranged from 496 µg/ft^2 in modern urban houses to 44,131 µg/ft^2 in R&M I houses. For window wells, geometric mean lead loadings ranged from 154 µg/ft^2 in modern urban houses to 9,828 µg/ft^2 in R&M I houses. For floors in rooms with windows, the geometric mean lead loadings were 58 µg/ft^2 in R&M I houses, 59 µg/ft^2 in R&M II houses, and 53 µg/ft^2 in R&M III houses. When measuring window sills, the geometric mean dust lead loadings were 460 µg/ft^2 for R&M I houses, 195 µg/ft^2 for R&M II houses, and 26 µg/ft^2 for R&M III houses. Geometric mean lead loadings for window wells were 9,828 µg/ft^2 in R&M I houses, 2,122 µg/ft^2 in R&M II houses, and 164 µg/ft^2 in R&M III houses. These geometric mean lead loadings are not directly comparable to HUD interim clearance standards and EPA clearance standard guidance for lead in house dust, both of which are surface specific (floors: 100 µg/ft^2; window sills: 500 µg/ft^2; window wells: 800 µg/ft^2) and based on wipe samples.

Geometric mean dust lead concentrations across all groups and surface types at 24 months were <2,000 µg/g, except for window sills in R&M I houses (6,725 µg/g) and in R&M II houses (2,914 µg/g), and window wells in R&M I houses (14,836 µg/g) and R&M II houses (5,669 µg/g). At 24 months, geometric mean dust loadings by group and by surface type were all <700 mg/ft^2, except for air ducts, which ranged from 6,454 mg/ft^2 to 33,929 mg/ft^2 across groups.

Table 15: Descriptive Statistics For Blood Lead Concentrations By Group At The 24-Month Campaign For Children With Initial Blood Lead Concentrations <15 μg/dL [a]

Study Group	n	Minimum (μg/dL)	Maximum (μg/dL)	Geometric Mean[a] (μg/dL)	S.D. on log scale	Lower 95% CI for GM (μg/dL)	Upper 95% CI for GM (μg/dL)
R&M I	11	2	15	6.6	0.372	5	8
R&M II	11	6	15	10.0	0.382	8	13
R&M III	10	6	15	9.3	0.330	8	12
Previously Abated [b]	15	6	13	9.6	0.355	7	12
Modern Urban	8	2	6	3.5	0.406	3	4

[a] GM values and confidence intervals were obtained from SAS® PROC MIXED.
[b] Excludes one child who received chelation therapy at 12 months due to a blood lead concentration of 53 μg/dL.

Figure 20: Geometric Mean Dust Lead Loadings By Surface Type And Study Group At The 24-Month Campaign

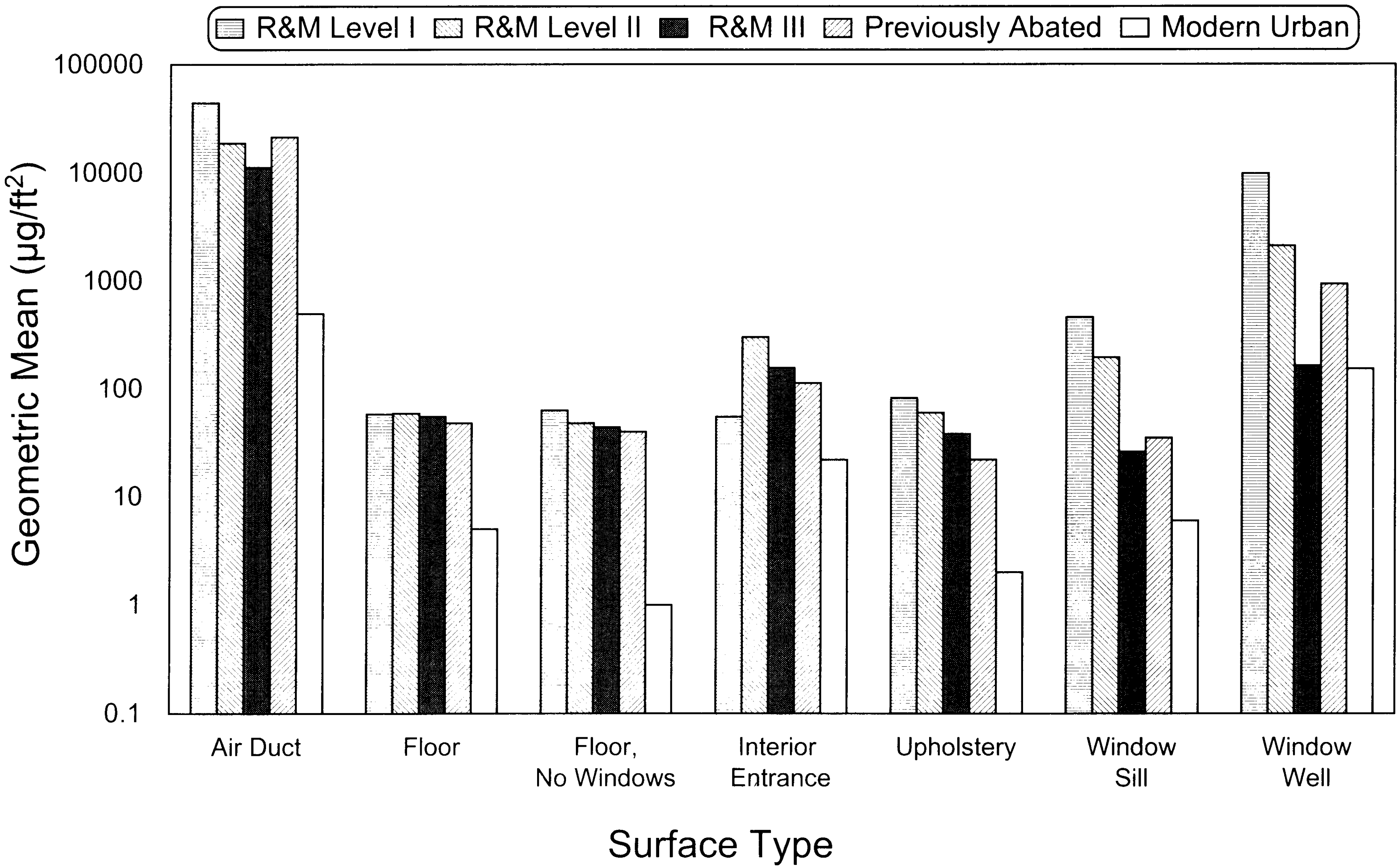


Figure 21: Geometric Mean Dust Lead Concentrations By Sample Type And Study Group At The 24-Month Campaign

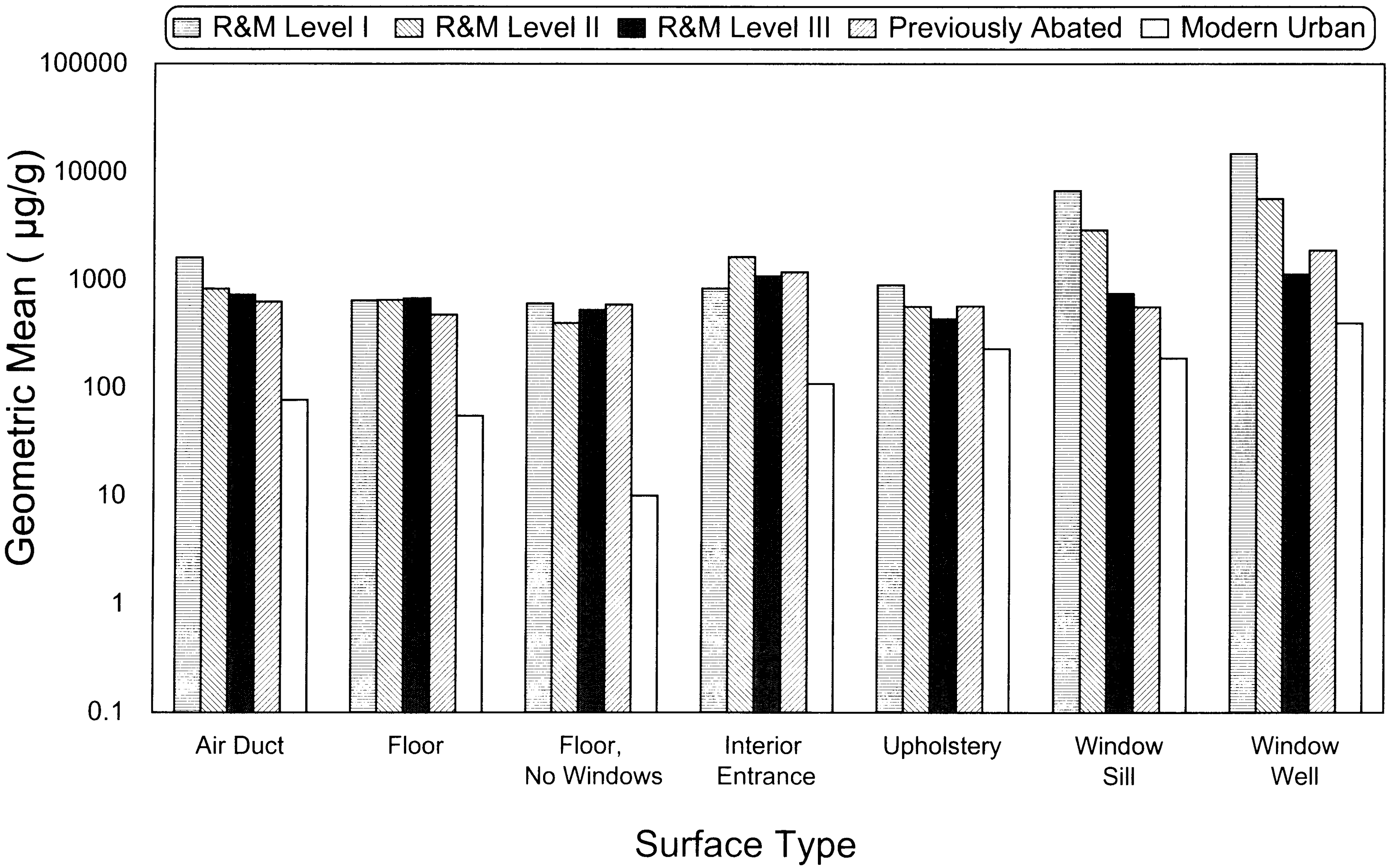
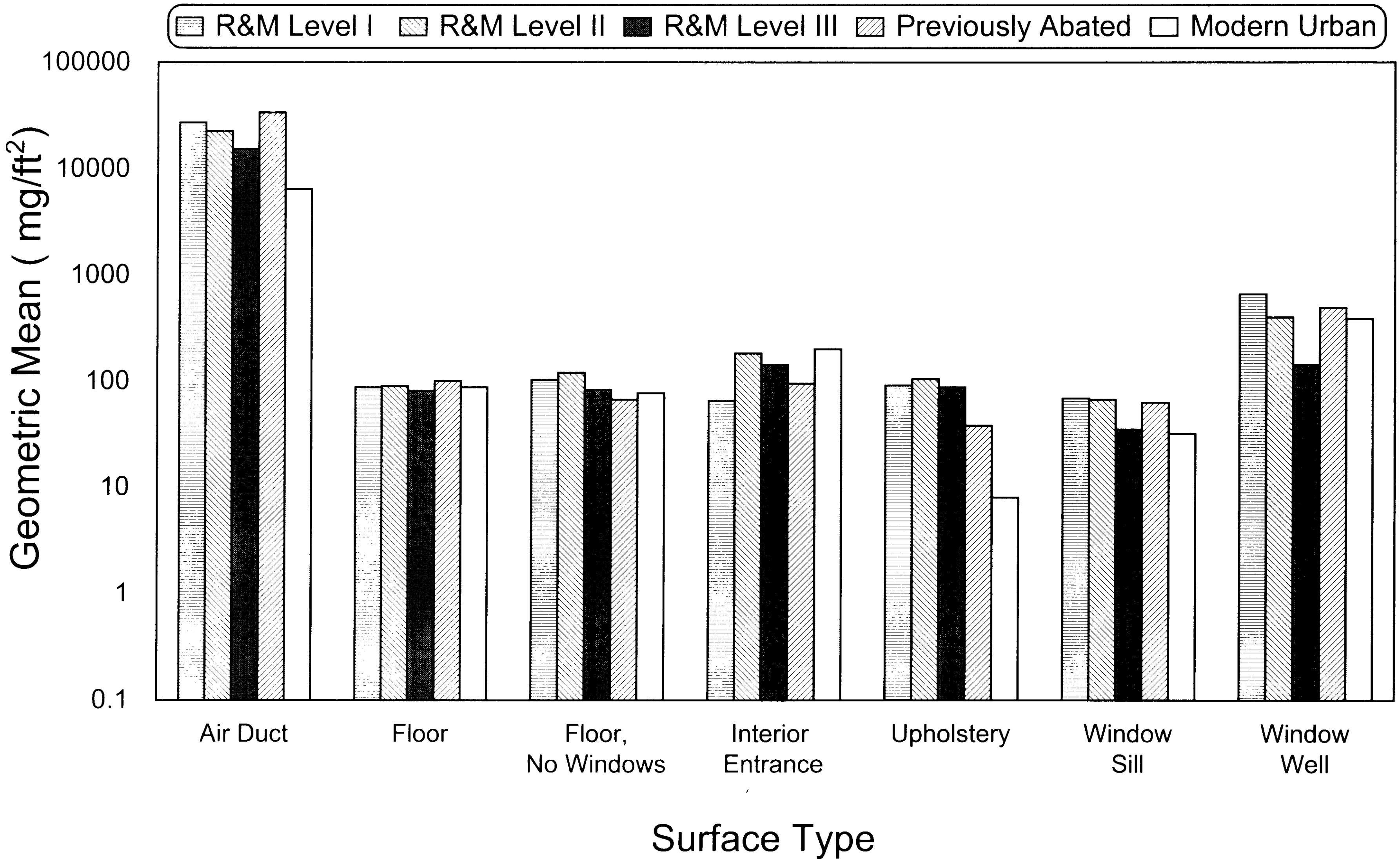


Figure 22: Geometric Mean Dust Loading By Sample Type And Study Group At The 24-Month Campaign



Modern urban houses continued to have the lowest lead loadings. At the 24-month campaign, geometric mean lead loadings were 22 µg/ft^2 across surface types, except for window wells (154 µg/ft^2) and air ducts (496 µg/ft ^{2}). At 24 months, R&M I houses had statistically significantly higher geometric mean lead loadings for window sills (460 µg/ft^2), and for window wells (9,828 µg/ft^2), compared to R&M III houses (26 µg/ft^2 for window sills, and 164 µg/ft^2 for window wells). Geometric mean lead loadings in R&M II houses were intermediate (195 µg/ft^2 for window sills and 2,122 µg/ft^2 for window wells).

At 24 months, modern urban houses continued to have the lowest geometric mean lead concentrations across all surface types (<400 µg/g). The geometric mean lead concentrations for interior entryways and interior floors across the other four study groups were higher and were not statistically different from each other. R&M I houses had statistically higher geometric mean lead concentrations for window sills (6,725 µg/g) and for window wells (14,836 µg/g) compared to R&M III houses, which had readings of 749 µg/g for window sills and 1,130 µg/g for window wells, and compared to R&M II houses, which had intermediate lead concentrations of 2,914 µg/g for window sills and 5,669 µg/g for window wells.

The five groups of houses were most similar to each other in terms of dust loadings. However, as with the other measures, dust loadings tended to be highest in R&M I houses, lowest in R&M III houses, and intermediate in R&M II houses. For windows wells, R&M I houses had a statistically higher geometric mean dust loading (663 mg/ft^2) than R&M III houses (143 mg/ft^2). R&M II houses had intermediate dust loadings (402 mg/ft^2).

<u>Summary Measures Of Dust Data For A House</u>

Summary measures of dust data for each house were calculated based on a weighted measure of the major surface types common to all campaigns to provide a general sense of the overall magnitude of house dust lead levels over time within and between groups. These summary measures were not used in the longitudinal data analysis. Lead loadings and dust loadings were weighted by the surface area sampled. Lead concentrations were weighted by the sample mass. The weighted measure within each house was calculated as the total mass of lead collected divided by the total area sampled (or total dust mass, depending on the dust endpoint). These weighted medians were computed based on samples collected from interior floors, window sills, and window wells.

Overall median weighted summary measures for dust lead loadings and concentrations and dust loadings by group are displayed in Table ES-1 and Figure ES-1. Median weighted summary measures are presented separately for floors, window sills and window wells in Figures ES-2 to ES-4 and Tables ES-2 and ES-3. Among R&M groups immediately after intervention and during two-years of follow-up, dust lead loadings, lead concentrations and dust loadings were lowest in R&M III houses, intermediate in R&M II houses, and highest in R&M I houses. Differences in lead loadings between R&M groups were primarily due to differences in lead concentrations and secondarily to differences in dust loadings (Table ES-1). Further, overall median lead concentrations in the modern urban houses at 24 months were three to 30 times lower than corresponding levels in the intervention groups, and overall median lead loadings in the modern urban houses were three to 83 times lower than corresponding levels in the intervention groups. The five study groups were most similar in terms of overall dust loadings (Table ES-1).

Paint Chips On Sampled Window Surfaces And Window Surface Conditions

For each sub-area included in a composite dust sample from window sills and window wells, field staff noted the presence or absence of paint chips and rated the surface condition (smooth and intact to rough and deteriorated). At 12-months and 24-months, observations of the presence of paint chips on window sills and window wells were reduced for all three R&M groups, relative to pre-intervention. The decline was greatest in R&M III houses, intermediate in R&M II houses, and lowest in R&M I houses. In R&M I houses and R&M II houses, paint chips were observed more frequently at 24-months than at 12-months post-intervention.

Similarly, 12-month and 24-month observations of surface conditions for window sills and window wells showed improvement over pre-intervention observations for all R&M groups. The improvement was greatest in R&M III houses and intermediate in R&M II houses for window sills, and similar in all three groups for window wells.

Lead In Soil

Descriptive statistics for drip-line soil lead concentrations obtained at the initial, six-month and 18-month campaigns for each study group are displayed in Table 16. These data are limited due to the lack of soil for most study houses. Soil lead concentrations in the 10 of 16 modern urban houses with drip-line soil were consistently low across time (geometric means <70 µg/g, range of individual values 6 to 747 µg/g). Geometric mean soil lead concentrations in the small numbers of houses in the other four study groups with drip-line soil were higher (geometric means 529 µg/g to 2,192 µg/g, range of individual values 46 µg/g to 15,968 µg/g). Drip-line soil was also tested immediately after the intervention in the R&M houses to determine if the interventions were associated with an increase in exterior soil lead concentrations. Based on limited data, no change was found in soil lead concentrations following intervention for R&M I and R&M II houses. The data were insufficient to assess the change in soil lead for R&M III houses.

Lead In Drinking Water

Geometric mean lead concentrations of drinking water were consistently 7 µg/L (ppb) across time for all five study groups (Table 17). Individual values ranged from less than the instrumental limit of detection (<LOD) to 175 µg/L (Table 17).

Table 16: Descriptive Statistics For Drip-Line Soil Lead Concentrations By Group Over Time

Campaign/ Study Group	n	Minimum (µg/g)	Maximum (µg/g)	Geometric Mean (µg/g)	S.D. on log scale	Lower 95% CI for GM (µg/g)	Upper 95% CI for GM (µg/g)
Initial							
R&M I	5	435	1,879	1,355	0.635	616	2,981
R&M II	5	626	15,968	1,755	1.432	297	10,386
R&M III	2	1,350	1,647	1,491	0.141	-	-
Previously Abated	2	1,570	3,061	2,192	0.472	-	-
Modern Urban	10	29	154	61	0.502	43	88
Six-Month							
R&M I	6	303	4,530	1,173	0.968	425	3,242
R&M II	6	424	2,608	1,101	0.705	526	2,306
R&M III	4	448	2,267	946	0.754	285	3,140
Previously Abated	2	304	1,473	669	1.115	-	-
Modern Urban	10	34	229	67	0.537	46	99
18-Month							
R&M I	6	182	6,916	1,161	1.191	333	4,051
R&M II	4	285	11,697	1,844	1.584	148	22,931
R&M III	3	395	1,746	710	0.791	100	5,067
Previously Abated	3	46	1,990	529	2.124	3	103,430
Modern Urban	10	6	747	69	1.398	25	187

Table 17: Descriptive Statistics For Water Lead Concentrations By Group Over Time

Campaign/ Study Group	n	Minimum (µg/L)	Maximum (µg/L)	Geometric Mean (µg/L)	S.D. on log scale	Lower 95% CI for GM (µg/L)	Upper 95% CI for GM (µg/L)
Initial							
R&M I	25	<LOD[a]	21	3	1.202	2	4
R&M II	21	1	73	7	1.152	4	12
R&M III	22	<LOD[a]	113	7	1.306	4	12
Previously Abated	16	<LOD[a]	22	1	1.311	1	3
Modern Urban	16	<LOD[a]	20	2	1.437	1	5
Six-Month							
R&M I	25	<LOD[a]	11	2	1.132	1	3
R&M II	23	<LOD[a]	17	3	1.184	2	5
R&M III	26	<LOD[a]	62	2	1.377	1	4
Previously Abated	14	<LOD[a]	17	1	1.222	1	3
Modern Urban	15	<LOD[a]	40	4	1.316	2	8
18-Month							
R&M I	24	<LOD[a]	24	3	1.096	2	4
R&M II	21	1	45	3	1.156	2	6
R&M III	28	<LOD[a]	28	2	0.995	1	3
Previously Abated	13	<LOD[a]	9	1	1.318	1	3
Modern Urban	14	<LOD[a]	175	2	1.854	1	6

[a] Generally <0.6 µg/L

Correlations Among Dust Lead Measurements Across Surface Types

Statistically significant ($p<.05$) correlations were found for dust lead loadings and for concentrations between most surface types at the 24-month campaign (Tables 18 and 19). For this correlation analysis, samples from similar surface types were mathematically composited (*i.e.*, first and second story floor samples) to avoid confounding among multiple surface types within a house. The highest correlation coefficients for these measures were observed between window sills and window wells (r=.48 for lead loadings and r=.61 for lead concentrations); between window sills and floors in rooms with windows (r=.49 for lead loadings and r=.61 for lead concentrations) and between air ducts and floors in rooms with windows (r=.49 for lead loadings and r=.66 for lead concentrations). Fewer statistically significant correlations were found between surface types for dust loadings (Table 20). Similar findings were obtained at 12-months.

Correlation Between Blood Lead And Dust Lead

Using blood lead concentration for the youngest child in each house at 24-months, statistically significant correlations were found between ln(children's blood lead) and ln(dust lead loadings) for floors in rooms with windows (r=.42), window sills (r=.29), and interior entryways (r=.25) (Table 21). The Pearson correlation coefficients for the association between ln(blood lead) and ln(dust lead concentration) were statistically significant for floors in rooms with windows (r=.45), interior entryways (r=.37), air ducts (r=.33), window wells (r=.26), and window sills (r=.25) (Table 21). Dust loadings were not significantly correlated with children's blood lead concentrations for any surface type at 24-months. Similar patterns of correlations were found between blood lead concentrations and dust lead measures at earlier campaigns (Table 21).

7.3 Longitudinal Data Analysis

Environmental Dust Model

The environmental dust model (described in Section 6.3) was developed for the data for lead loadings, lead concentrations, and dust loadings. The dependent variable for the environmental model, called factor1, was obtained from a factor analysis and accounted for most of the variability of environmental dust lead. A more detailed discussion of the factor analysis is provided in Section 6.3.

Figures 23(a-c) are plots of the least square mean estimates for each of the three dust endpoints (lead loadings and concentrations, and dust loadings) derived from the environmental model when fit to data from the three R&M groups only. Figures 24(a-c) are plots of the least square mean estimates derived from the same model fit to data from all five groups. Note that solid lines are used to connect the points in these plots. This is done for ease of display. These lines should not be taken to indicate that trends in the intervals between campaigns are known. Study group, campaign and the interaction of study group and campaign were found to be

Table 18: Correlations Between Dust Lead Concentrations At The 24-Month Campaign

Pearson Correlation Coefficient (r) / Number of Observations (n)

		Air Duct	**Interior Entryway**	**Floors in Rooms with Windows**	**Window Sill**	**Upholstery**	**Window Well**	**Floors in Rooms without Windows**
Air Duct	r	-	0.34**	0.66**	0.61**	-	0.49**	-0.14
	n		56	56	56	0	55	23
Interior Entryway	r	-	-	0.37**	0.35**	0.27	0.25*	0.39**
	n			100	100	42	99	54
Floors in Rooms with Windows	r	-	-	-	0.61**	0.36*	0.51**	0.48**
	n				100	42	99	54
Window Sill	r	-	-	-	-	0.53**	0.61**	0.37**
	n					42	99	54
Upholstery	r	-	-	-	-	-	0.53**	0.42*
	n						42	29
Window Well	r	-	-	-	-	-	-	0.32*
	n							53
Floors in Rooms without Windows	r	-	-	-	-	-	-	-
	n							

*   p-value is < .05   ** p-value is < .01

Table 19: Correlations Between Dust Lead Loadings At The 24-Month Campaign

Pearson Correlation Coefficient (r) / Number of Observations (n)

		Air Duct	Interior Entryway	Floors in Rooms with Windows	Window Sill	Upholstery	Window Well	Floors in Rooms without Windows
Air Duct	r	-	0.20	0.49**	0.51**	-	0.23	-0.03
	n		56	56	56	0	55	23
Interior Entryway	r	-	-	0.31**	0.17	0.19	0.11	0.28*
	n			100	100	42	99	54
Floors in Rooms with Windows	r	-	-	-	0.49**	0.47**	0.35**	0.38**
	n				100	42	99	54
Window Sill	r	-	-	-	-	0.45**	0.48**	0.24
	n					42	99	54
Upholstery	r	-	-	-	-	-	0.15	0.46*
	n						42	29
Window Well	r	-	-	-	-	-	-	0.03
	n							53
Floors in Rooms without Windows	r	-	-	-	-	-	-	-
	n							

* p-value is < .05 ** p-value is < .01

Table 20: Correlations Between Dust Loadings At The 24-Month Campaign

Pearson Correlation Coefficient (r) / Number of Observations (n)

		Air Duct	Interior Entryway	Floors in Rooms with Windows	Window Sill	Upholstery	Window Well	Floors in Rooms without Windows
Air Duct	r	-	-0.09	0.03	0.07	-	-0.18	-0.15
	n		56	56	56	0	55	23
Interior Entryway	r	-	-	0.50**	0.09	-0.04	0.09	0.13
	n			100	100	42	99	54
Floors in Rooms with Windows	r	-	-	-	0.02	0.10	0.20*	0.30*
	n				100	42	99	54
Window Sill	r	-	-	-	-	0.19	0.37**	0.09
	n					42	99	54
Upholstery	r	-	-	-	-	-	0.05	0.05
	n						42	29
Window Well	r	-	-	-	-	-	-	-0.01
	n							53
Floors in Rooms without Windows	r	-	-	-	-	-	-	-
	n							

* p-value is < .05 ** p-value is < .01

Table 21: Correlations Between Blood Lead and Dust Lead Using The Youngest Child Per Household In Continuing Houses By Campaign

Pearson Correlation Coefficient (r) / Number of Observations (n)

Sample Type / Correlated with Blood Lead		Initial Lead Conc.	Initial Lead Loading	Six-Month Lead Conc.	Six-Month Lead Loading	12-Month Lead Conc.	12-Month Lead Loading	18-Month Lead Conc.	18-Month Lead Loading	24-Month Lead Conc.	24-Month Lead Loading
Interior Entryway	r	0.49**	0.46**	0.23*	0.24*	0.29**	0.15	0.31**	0.10	0.37**	0.25*
	n	107	107	99	99	93	93	87	87	80	80
Floors in Rooms with Windows	r	0.42**	0.46**	0.47**	0.44**	0.44**	0.35**	0.40**	0.34**	0.45**	0.42**
	n	107	107	99	99	93	93	87	87	80	80
Floors in Rooms without Windows	r	0.39**	0.38**	0.38**	0.26	0.32*	0.32*	0.22	0.26	- 0.09	0.16
	n	56	56	54	54	51	51	48	48	44	44
Upholstery	r	0.61**	0.47**	0.44	0.06	0.41**	0.38**	-	-	0.19	0.20
	n	59	59	9	9	40	40	0	0	29	32
Window Sill	r	0.41**	0.41**	0.12	0.13	0.18	0.16	0.28**	0.22*	0.25*	0.29**
	n	107	107	99	99	93	93	87	87	80	80
Window Well	r	0.39**	0.44**	0.20*	0.06	0.20	0.10	0.26*	0.16	0.26*	0.19
	n	106	106	99	99	92	92	87	87	79	79
Air Duct	r	-0.40	0.13	0.59*	0.43	0.37**	0.32*	-	-	0.33*	0.33*
	n	29	29	12	12	53	53	0	0	47	47

* p-value is 05 ** p-value is 01

Figure 23a: R&M Groups Environmental Model For Dust Lead Concentration

Least Squares Estimates By Group And Campaign

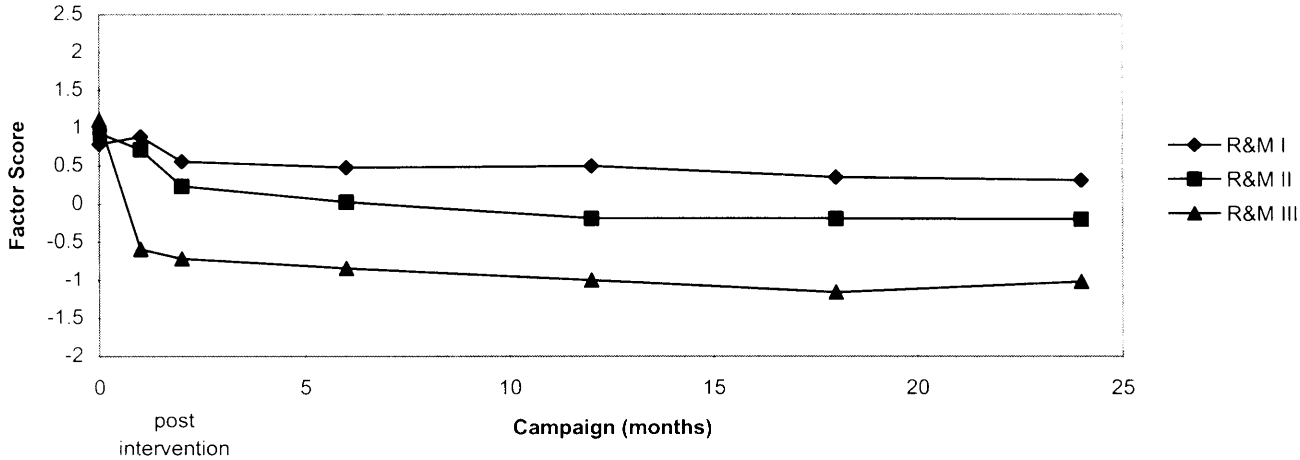


Figure 23b: R&M Groups Environmental Model For Dust Lead Loading

Least Squares Estimates By Group And Campaign

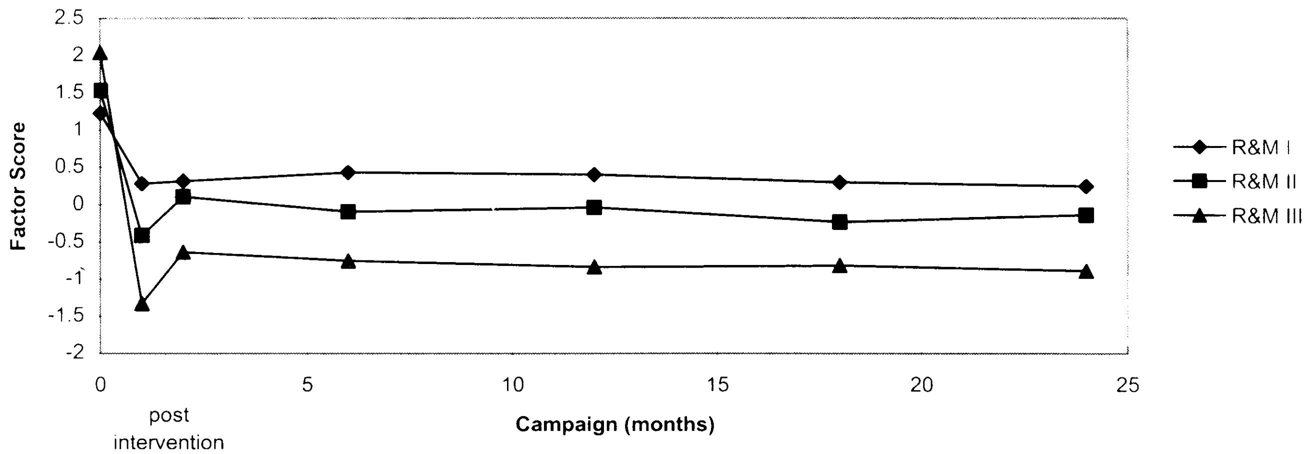


Figure 23c: R&M Groups Environmental Model For Dust Loading

Least Squares Estimates By Group And Campaign

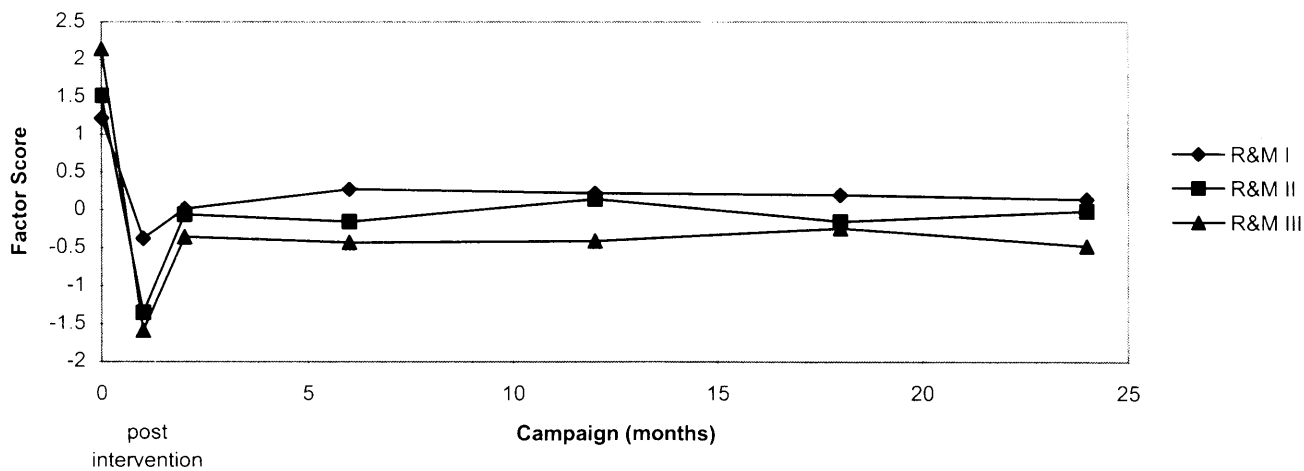


Figure 24a: Five Group Environmental Model For Dust Lead Concentration
Least Squares Estimates By Group And Campaign

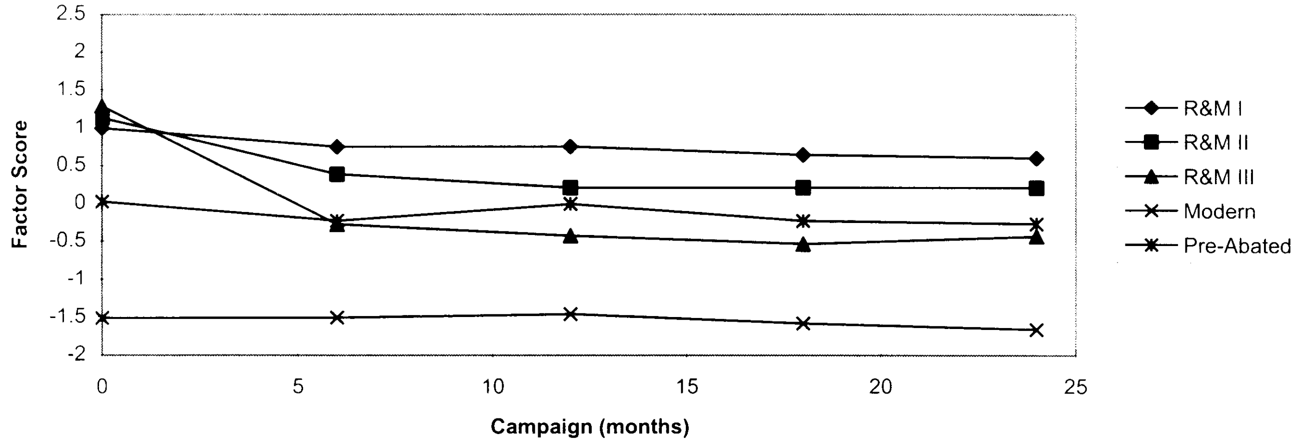


Figure 24b: Five Group Environmental Model For Dust Lead Loading
Least Squares Estimates By Group And Campaign

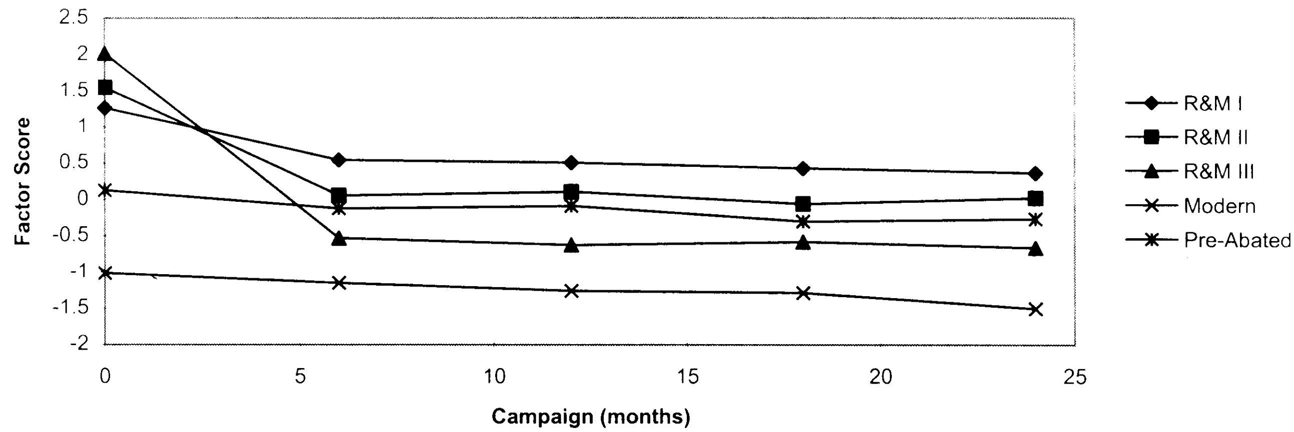
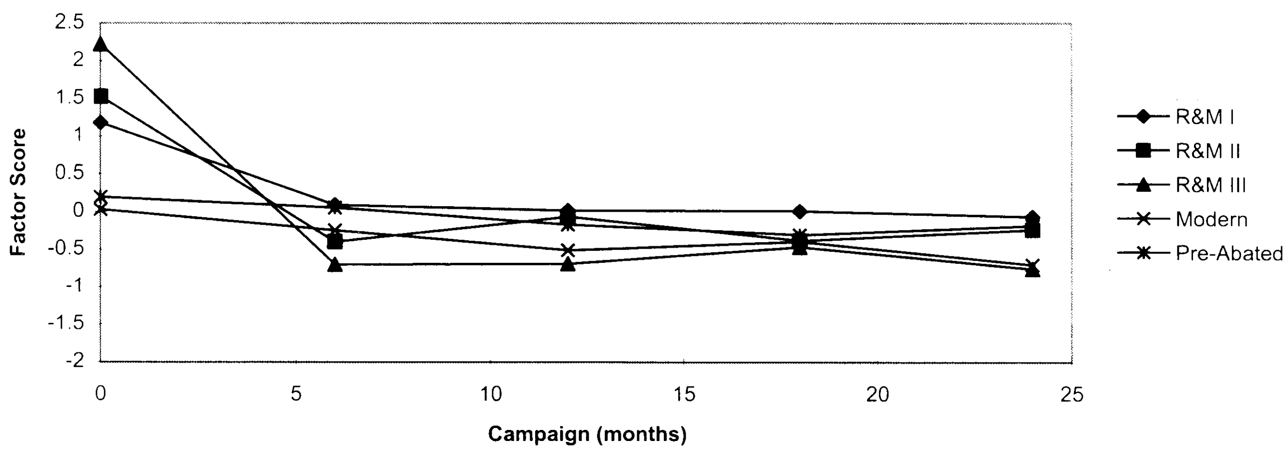


Figure 24c: Five Group Environmental Model For Dust Loading
Least Squares Estimates By Group And Campaign



statistically significant in all six applications of the environmental model, after controlling for season and with house as a random effect. The significant interaction term indicates that the relationship between group and campaign for the three dust endpoints is not the same across study groups. Season was found to have a significant fixed effect (p-value   .05) in the models fit to the lead loading and dust loading data from the three R&M groups and the model fit to dust loading data from the five study groups. Housing characteristics, such as degree of setback from the street and the presence of a porch, were not significant additions to the statistical models for dust lead loadings and for concentrations in the presence of season, group and campaign. The main findings of the applications of the environmental model, when controlling for season and including random effects for houses, are listed below. Environmental model results are presented in Appendix F.

<u>Environmental Dust Model -- Comparison Of Groups At Specific Campaigns (Cross-Sectional)</u>

- Pre-intervention dust <u>lead loadings</u> were significantly lower in R&M I houses than in R&M II and R&M III houses. During follow-up, R&M III houses consistently had the lowest lead loadings, R&M I the highest lead loadings, and R&M II had intermediate lead loadings, when controlling for season. Statistically significant differences were found between the three R&M groups at each post-intervention campaign during the two years of follow-up, except for between R&M I houses and R&M II houses at two months and at 24 months. Modern urban houses had statistically significantly lower lead loadings than each of the other four study groups at each campaign (baseline, six months, 12 months, 18 months and 24 months).

- Pre-intervention dust <u>lead concentrations</u> were not significantly different across the three R&M groups. During follow-up, dust lead concentration was lowest in R&M III houses, highest in R&M I houses, and intermediate in R&M II houses, when controlling for season. Lead concentrations were significantly lower (generally $p<.01$) in R&M III houses than in R&M I and R&M II houses at all post-intervention data collection campaigns. Only at 12 months, were lead concentrations in R&M II houses significantly lower than those in R&M I houses. R&M I-III houses and previously abated house all had significantly higher dust lead concentrations during follow-up than modern urban houses. Lead concentrations in R&M III houses were not significantly different from those in previously abated houses after the six-month campaign.

- At pre-intervention, <u>dust loadings</u> were significantly higher in R&M III houses than in R&M I and R&M II houses. During follow-up, dust loadings were lowest in R&M III houses, highest in R&M I houses, and intermediate in R&M II houses. Except for at two months and at 18 months post-intervention, dust loadings in R&M III houses were significantly less than those in R&M I houses during follow-up. Dust loadings in R&M II houses were statistically significantly less than those in R&M I houses at post-intervention. Dust loadings in the modern urban houses were generally not statistically significantly different from those in the other four groups during the two years of follow-up.

<u>Environmental Dust Model -- Changes Over Time Within Groups</u>

- For all three R&M groups, lead loadings during the two years of follow-up were statistically significantly lower than the corresponding pre-intervention lead loadings. Lead loadings between two months and 24 months were significantly higher than the corresponding lead loadings immediately post-intervention for R&M III houses, but not for R&M I houses and R&M II houses. Further, no statistically significant changes in dust lead loadings were found within any of the R&M groups between two months and 24 months post-intervention.

- R&M I intervention was not associated with a statistically significant reduction in dust lead concentration. In R&M II and R&M III houses, lead concentrations were significantly lower at all post-intervention campaigns through 24 months compared to baseline, except for R&M II houses immediately after intervention. R&M III was the only R&M group to have a significant reduction in lead concentration immediately after the intervention. Further, no statistically significant changes in dust lead concentrations were found within any of the R&M groups between two months and 24 months after intervention.

- Dust loadings were reduced significantly immediately after intervention and remained significantly below pre-intervention levels during two years of follow-up in all there groups of R&M houses, despite significant increases in dust loadings at two months in R&M II and R&M III houses. No statistically significant changes in dust loadings were found within the R&M groups between two-months and 24-months after intervention.

- With one exception, statistically significant changes were not found for dust lead loadings, lead concentrations and dust loadings in modern urban and previously abated houses during two years of follow-up, despite downward trends in lead loadings and dust loadings in both groups. At 24 months, dust loadings in the modern urban houses were significantly lower than the baseline dust loadings.

Blood Lead Comparison Model

The main findings of the comparison model (see Section 6.3) for investigating blood lead changes within and between groups are listed below. The model was fit separately for children with initial blood lead concentrations <15 µg/dL and for those with initial blood lead concentrations ≥15 µg/dL. Figures 25(a,b) are plots of the predicted blood lead concentrations based on the longitudinal data analysis of children with baseline blood lead concentrations <15 µg/dL in the three R&M groups and in all five study groups, when controlling for age and season. Figures 26(a,b) are plots of the predicted blood lead concentrations based on the analysis of children with baseline blood lead concentrations ≥15 µg/dL in the three R&M groups and in all five study groups, when controlling for age and season. Tables 22 and 23 displays the predicted blood lead concentrations with 95 percent confidence intervals for children with initial blood lead

Table 22: Predicted Blood Lead Concentration (PbB, µg/dL) By Group And By Campaign In Children With Initial PbB <15 µg/dL*

Study Group	Initial Campaign Predicted PbB (95% CI) n	Two Month Campaign Predicted PbB (95% CI) n`	Six Month Campaign Predicted PbB (95% CI) n	12-Month Campaign Predicted PbB (95% CI) n	18-Month Campaign Predicted PbB (95% CI) n	24- Month Campaign Predicted PbB (95% CI) n
R&M I	7.3 (6.1 to 8.6) 25	7.8 (6.5 to 9.5) 23	8.1 (6.7 to 9.8) 20	7.2 (5.6 to 9.3) 15	6.7 (4.9 to 9.2) 12	6.4 (4.6 to 8.9) 11
R&M II	9.4 (8.2 to 10.8) 17	10.1 (8.7 to 11.6) 15	11.0 (9.5 to 12.6) 15	9.9 (8.6 to 11.4) 15	9.7 (8.0 to 11.7) 12	9.2 (7.5 to 11.3) 11
R&M III	10.1 (8.3 to 12.2) 18	11.4 (9.1 to 14.3) 15	11.3 (9.0 to 14.0) 16	9.8 (7.7 to 12.4) 13	9.0 (7.0 to 11.6) 12	8.7 (6.8 to 11.2) 10
Previously Abated	10.6 (9.3 to 12.0) 13	not applicable	14.2 (12.0 to 16.8) 12	12.2 (10.6 to 14.0) 12	12.2 (9.5 to 15.6) 9	9.9 (7.7 to 12.8) 9
Modern Urban	3.2 (2.7 to 3.8) 19	not applicable	4.0 (3.3 to 4.8) 16	3.7 (3.2 to 4.4) 14	3.5 (3.0 to 4.3) 15	3.2 (2.7 to 3.8) 15

* Based on the application of the comparison model for longitudinal data analysis described in Section 6.3.

Table 23: Predicted Blood Lead Concentration (PbB, µg/dL) By Group And By Campaign In Children With Initial PbB≥15 µg/dL*

Study Group	Initial Campaign Predicted PbB (95% CI) n	Two Month Campaign Predicted PbB (95% CI) n`	Six Month Campaign Predicted PbB (95% CI) n	12-Month Campaign Predicted PbB (95% CI) n	18-Month Campaign Predicted PbB (95% CI) n	24- Month Campaign Predicted PbB (95% CI) n
R&M I	17.9 (16.5 to 19.4) 8	14.5 (12.8 to 16.4) 6	13.6 (12.3 to 15.0) 6	11.5 (8.1 to 16.4) 3	11.8 (9.9 to 14.1) 4	10.3 - 2
R&M II	21.4 (18.5 to 24.8) 14	18.0 (15.1 to 21.4) 9	15.8 (14.0 to 17.8) 13	15.2 (12.6 to 18.3) 9	14.2 (12.3 to 16.4) 10	14.5 (11.7 to 18.0) 7
R&M III	21.7 (18.9 to 24.8) 17	19.5 (16.7 to 22.8) 13	16.1 (13.8 to 18.7) 14	14.8 (12.6 to 17.3) 13	13.6 (11.3 to 16.3) 12	12.6 (10.6 to 15.0) 12
Previously Abated	20.3 (18.4 to 22.4) 10	not applicable	16.9 (14.6 to 19.6) 8	15.5 (12.9 to 18.7) 7	14.8 (12.4 to 17.7) 7	13.4 (10.6 to 16.8) 6
Modern Urban	- - 0	not applicable	- - 0	- - 0	- - 0	- - 0

* Based on the application of the comparison model for longitudinal data analysis described in Section 6.3.

Figure 25a: R&M Groups Comparison Model, Initial PbB < 15 µg/dL

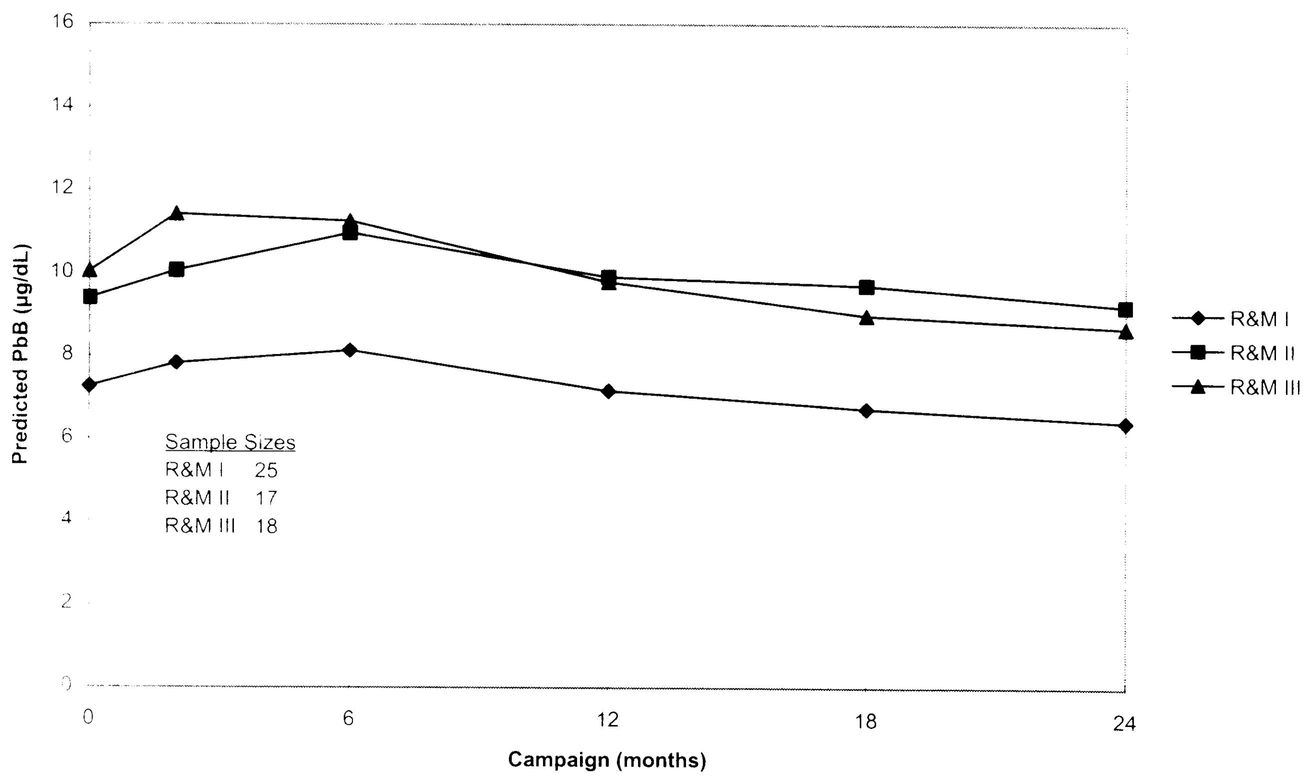


Figure 25b: Five Group Comparison Model, Initial PbB < 15 µg/dL

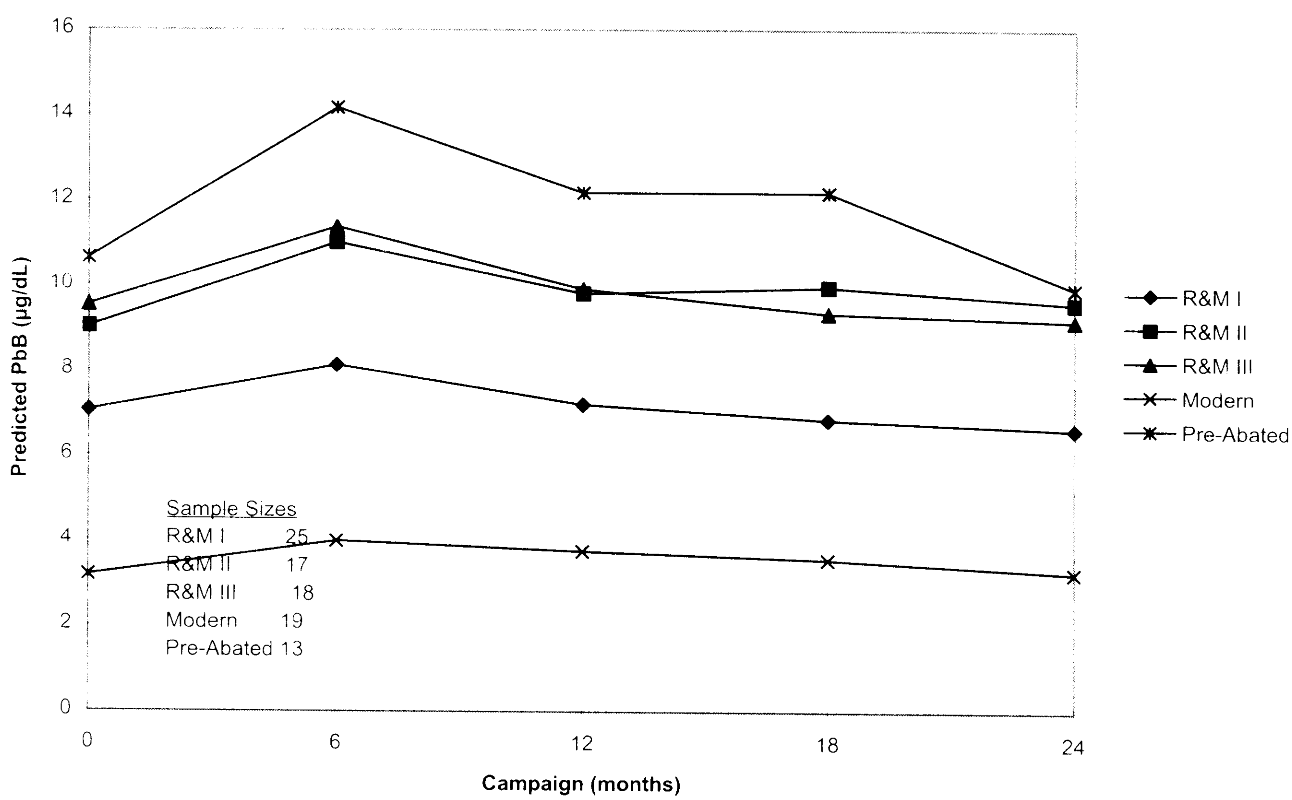


Figure 26a: R&M Groups Comparison Model, Initial PbB ≥ 15 µg/dL

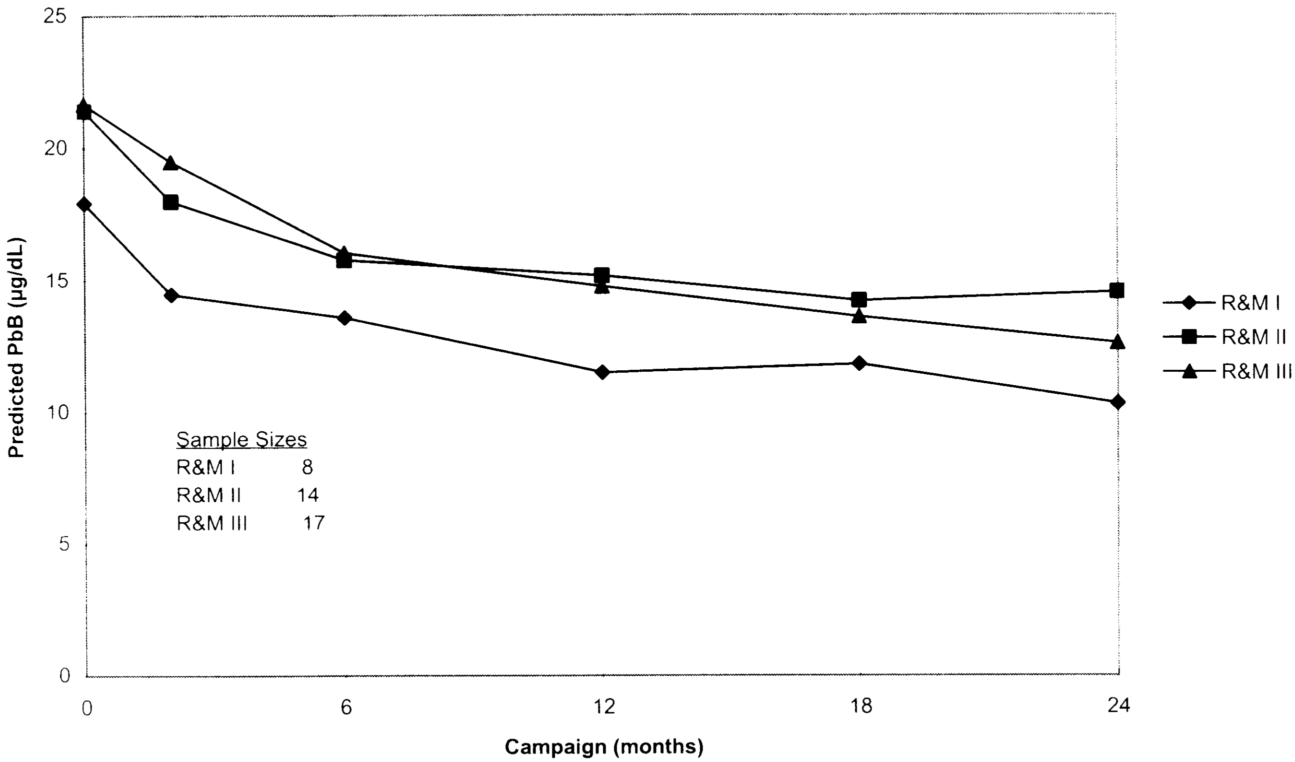
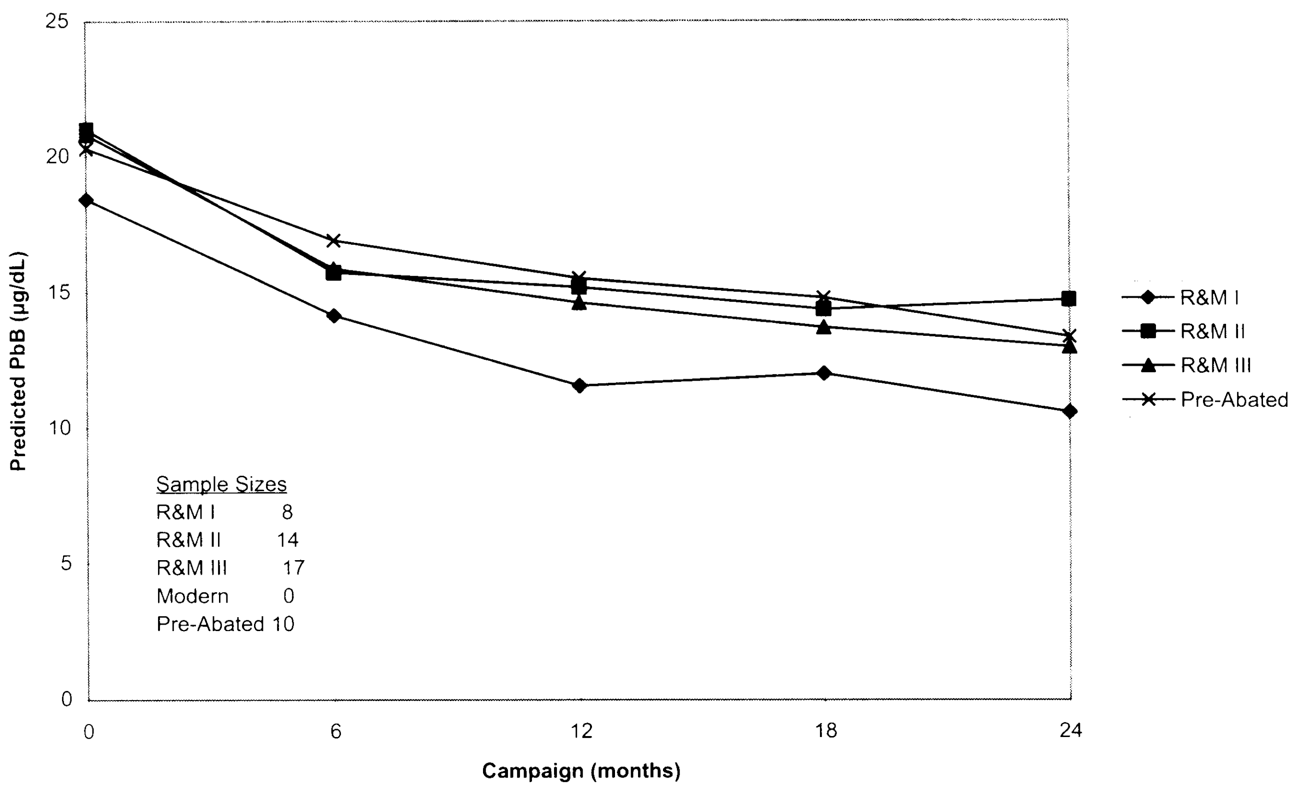


Figure 26b: Five Group Comparison Model, Initial PbB ≥ 15 µg/dL



concentrations <15 µg/dL and ≥15 µg/dL, by study group. The blood lead model results are also presented in Appendix F.

Children With Baseline Blood Lead Concentration <15 µg/dL

- The interaction between group and campaign was not statistically significant and the models were refitted without the interaction term. Age and season, but not gender, were found to be statistically significant in applications of the comparison model.

- For children with baseline blood lead concentrations <15 µg/dL, R&M I children tended to have lower blood lead concentrations at each campaign, including baseline, compared to R&M III children. Predicted blood lead levels declined over time in all three R&M groups and the campaign variable was significant. However, no statistically significant differences in predicted blood lead concentration were found between and within individual R&M groups during the two years of follow-up, controlling for age, gender and season (Table 22). The group variable was statistically significant in the three R&M group model and the five group model, when controlling for age, gender, and season.

- Controlling for age and season, children in modern urban houses had blood lead concentrations that were statistically lower than those of children in each of the other four study groups at every data collection campaign. No statistically significant changes in children's blood lead concentration were found within this group during the two years of follow-up (Table 22).

- Children with initial blood lead concentrations <15 µg/dL in the previously abated control houses had no statistically significant changes in geometric mean blood lead concentrations during two years of follow-up compared to baseline, controlling for age, gender, and season.

Children With Baseline Blood Lead Concentrations ≥15 µg/dL

- None of the children in the modern urban group had blood lead concentrations ≥15 µg/dL (all were 10 µg/dL). For the children in the other four groups with initial blood lead concentration ≥15 µg/dL, a statistically significant downward trend in blood lead concentration was found during follow-up, when controlling for age, season, and group. (It should be noted that the only one child in the R&M I group had an initial blood lead concentration ≥20 µg/dL). The decline in blood lead concentration across groups was greatest between baseline and 12 months. By 24 months, the predicted average blood lead concentrations were between 10.3 and 14.5 µg/dL across groups (Table 23).

Exposure Model Fitted To Blood Lead Concentration Data

The main findings of the exposure models (see Section 6.3) used to investigate the relationship between blood lead concentration and dust lead (loading and concentration) are below:

- Age, age squared, and season (summer vs other seasons) were significant contributors to the model for the three R&M groups and for all five groups. Gender was not. Various measures of hand-to-mouth activity (high vs. low) were not found to be consistently significant contributors to the model.[f]

- Controlling for age, campaign, dust factor1, and factor2, the seasonal change in children's blood lead concentration was estimated to be +1.2 µg/dL in summer, relative to the other seasons.

- Using all five study groups in the model, dust lead loadings and concentrations (factor1 and factor2) were significantly related to children's blood lead concentration after adjusting for age, season, campaign and the inclusion of random effects for houses and multiple children in each house. Factor1 and factor2 were not found to be significant contributors to the model for the three R&M groups.

- The interactions of factor1 and factor2 with campaign were not statistically significant for lead concentration factors and lead loading factors. For this reason, the exposure models do not include these interaction terms.

Figures 27a and 27b are partial-residual plots of blood lead concentration versus factor1 dust lead loading and factor1 dust lead concentration, derived from the exposure model for all five study groups. These types of plots reflect the relationship between the dependent variable (blood lead concentration) and a specific independent variable (factor1 dust lead) after both variables are adjusted for all of the other independent variables in the model. The slope of the regression line in the figure is different from zero and positive, indicating a statistically significant relationship between blood lead concentration and dust lead loading, and between blood lead concentration and dust lead concentration. The positive slope indicates that blood lead concentration increases as exposure increases. Factor1 is a composite measure of lead exposure in a house based on a linear combination of floor, window sill, and window well data. Due to the nature of factor1, it is not possible to interpret the model findings in terms of a unit change in blood lead concentration predicted for a unit change in factor1.

[f] One measure of hand-to-mouth activity had statistical significance using data from all five study groups through the 24-month campaign. Within some groups, one of the various measures of hand-to-mouth activity reached statistical significance (.05), or borderline significance.

Figure 27a: All Groups, Lead Loading Exposure Model, Adjusted Residual Plot

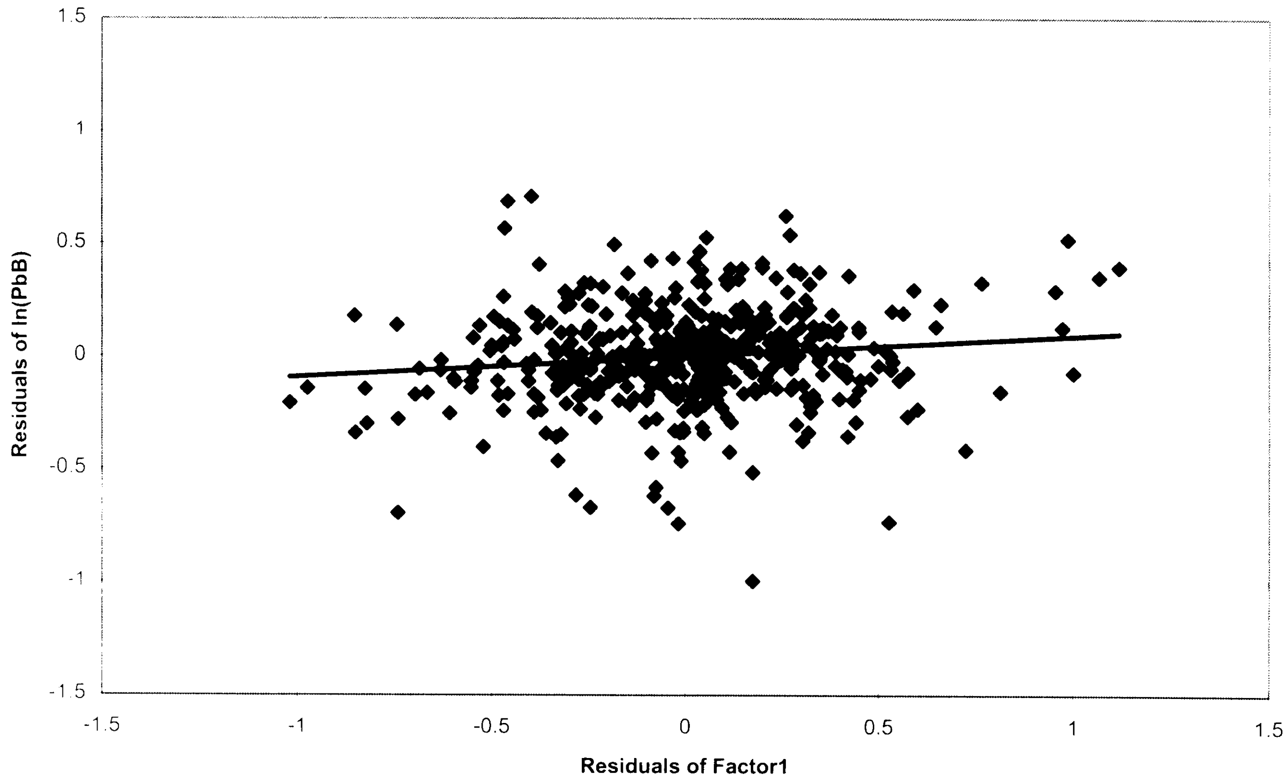
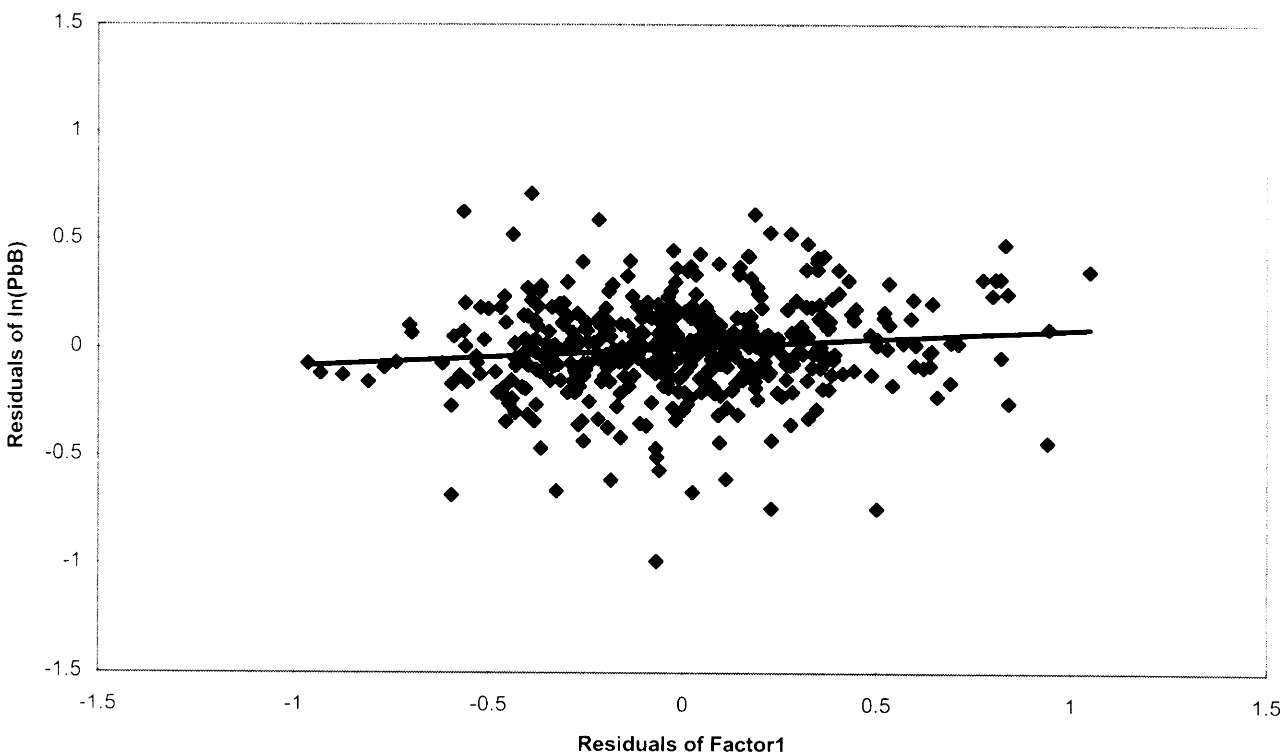


Figure 27b: All Groups, Lead Concentration Exposure Model, Adjusted Residual Plot



Carpet Dust Data

Although this study was not designed to study carpets, longitudinal data analysis was performed to determine whether dust lead loadings and concentrations and dust loadings varied by the amount of carpet included in the composite dust samples from floors. Dust loadings and dust lead loadings tended to increase as the amount of carpet area included in composite samples increased, when accounting for group, campaign, the interaction of group and campaign, and story (1st floor vs. 2nd floor). Dust lead concentrations, however, decreased slightly. This pattern of findings suggests that carpets are dust traps or sinks. The significance of this pattern is not clear; other analyses indicated that the amount of carpet included in composite samples was not a predictor of children's blood lead concentrations.

The reader is referred to Section 2.0 for a discussion of the study findings.

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APPENDIX A

Examples of Dust Lead and Blood Lead Letters Sent to Participating Households

Kennedy Krieger Institute

A comprehensive resource for children with disabilities

Dear Parent,

As you know, the dust in your home was tested for lead on as part of the special Kennedy Krieger Institute project sponsored by the U.S. Environmental Protection Agency (EPA). The chart below will show the areas where dust was collected in your home. Remember there is no rule for how much lead is allowed in the dust from a house like yours. However, we have placed an * next to areas where the amount of lead was higher than might be found in a completely renovated house. Please give these areas special attention when you are cleaning the house.

1st Floor	Status	
Exterior Entrance	=	
Floor	=	Rooms with windows
Window Sills	=	
Window Wells	=	
Floor	=	Rooms without windows
Interior Entrance	=	

2nd Floor	Status	
Window Wells	=	
Window Sills	=	
Floor	=	Rooms with windows

If you have any questions, please contact me at 550-9241. Thank you for your time in this study.

Sincerely,

707 North Broadway Baltimore, Maryland 21205 (410) 550-9000/Telephone (410) 550-9344/Facsimile (410) 550-9806/TTY

Kennedy Krieger Institute

A comprehensive resource for children with disabilities

Dear Ms.

This is to inform you that your child, ________________ has a blood lead elevation based on test results of the blood which was taken from the arm at the Kennedy Krieger Lead Clinic on _______ . His/her blood lead test result is ___ micrograms/deciliter. This places your child in CDC Class _____ This test result should be given to your child's primary health care provider soon. As you know, the test was performed as part of the special project sponsored by the U.S. Environmental Protection Agency.

If you have any questions please contact me at or the clinic nurse at ________________

Sincerely,

Outreach Coordinator

KKI Medical Records

707 North Broadway Baltimore, Maryland 21205 (410) 550-9000/Telephone (410) 550-9344/Facsimile (410) 550-9806/TTY

APPENDIX B

Descriptive Statistics for Dust Data at 24 Months

Table B-1: Descriptive Statistics For Dust Lead Concentrations By Surface Type And Study Group At The 24-Month Campaign

Surface Type	Study Group	n	Minimum (µg/g)	Maximum (µg/g)	Geometric Mean[a] (µg/g)	S.D. on log scale	Lower 95% CI for GM (µg/g)	Upper 95% CI for GM (µg/g)
Air Duct	R&M-I	8	698	5,125	1,615	0.594	938	2,653
	R&M-II	12	180	26,999	830	1.411	333	2,034
	R&M-III	15	178	19,602	731	1.119	394	1,359
	Previously Abated	9	169	9,123	629	1.226	245	1,615
	Modern Urban	10	30	219	77	0.637	49	121
Interior Entryway	R&M-I	21	<1	25,537	838	2.307	293	2,395
	R&M-II	22	298	75,316	1,640	1.478	852	3,158
	R&M-III	27	202	9,512	1,086	0.879	767	1,538
	Previously Abated	13	252	5,935	1,187	0.933	675	2,085
	Modern Urban	14	14	735	109	1.149	56	212
Floors in Rooms with Windows	R&M-I	43	59	14,675	648	1.212	412	1,021
	R&M-II	44	93	32,294	655	1.274	430	998
	R&M-III	54	31	23,960	654	1.382	412	1,037
	Previously Abated	26	135	8,154	477	0.988	287	792
	Modern Urban	29	20	148	55	0.614	43	70
Floors in Rooms without Windows	R&M-I	14	144	3,907	607	0.965	347	1,059
	R&M-II	15	127	2,404	399	0.844	250	636
	R&M-III	14	110	6,057	527	1.037	290	959
	Previously Abated	6	37	4,155	592	1.750	94	3,712
	Modern Urban	3	<1	307	10	4.435	<1	553,486
Window Sill	R&M-I	40	316	122,743	6,725	1.344	4,317	10,477
	R&M-II	44	134	74,311	2,914	1.589	1,745	4,865
	R&M-III	54	2	41,694	749	1.624	476	1,180
	Previously Abated	26	<1	20,097	563	2.121	227	1,393
	Modern Urban	28	30	790	188	0.952	115	309
Upholstery	R&M-I	12	133	9,399	900	1.148	434	1,866
	R&M-II	9	382	1,459	568	0.506	385	838
	R&M-III	12	135	1,077	436	0.711	277	684
	Previously Abated	4	243	2,863	572	1.106	98	3,325
	Modern Urban	4	46	3,512	230	2.000	10	5,530
Window Well	R&M-I	35	319	137,132	14,836	1.331	9,217	23,882
	R&M-II	42	115	78,121	5,669	1.491	3,301	9,734
	R&M-III	53	212	28,551	1,130	1.087	811	1,575
	Previously Abated	26	191	34,556	1,893	1.361	889	4,032
	Modern Urban	28	87	1,139	398	0.547	301	526

[a] GM values and confidence intervals for floors (rooms with windows), window sills, and window wells were obtained from SAS® PROC MIXED

Table B-2: Descriptive Statistics For Dust Lead Loadings By Surface Type And Study Group At The 24-Month Campaign

Surface Type	Study Group	n	Minimum ($\mu g/ft^2$)	Maximum ($\mu g/ft^2$)	Geometric Mean[a] ($\mu g/ft^2$)	S.D. on log scale	Lower 95% CI for GM ($\mu g/ft^2$)	Upper 95% CI for GM ($\mu g/ft^2$)
Air Duct	R&M-I	8	4,445	432,238	44,131	1.639	11,212	173,700
	R&M-II	12	1,261	306,104	18,767	1.637	6,634	53,092
	R&M-III	15	146	2,802,218	11,216	2.561	2,716	46,314
	Previously Abated	9	427	755,011	21,358	2.083	4,307	105,901
	Modern Urban	10	89	1,421	496	0.876	265	928
Interior Entryway	R&M-I	21	<1	14,940	55	3.564	11	277
	R&M-II	22	2	201,516	301	2.464	101	897
	R&M-III	27	8	7,382	156	1.834	75	322
	Previously Abated	13	8	4,238	113	2.265	29	444
	Modern Urban	14	1	145	22	1.637	9	56
Floor in Rooms with Windows	R&M-I	43	<1	3,747	58	1.743	32	104
	R&M-II	44	1	3,843	59	1.867	30	118
	R&M-III	54	1	2,399	53	1.596	30	93
	Previously Abated	26	6	1,669	48	1.404	27	88
	Modern Urban	29	1	28	5	0.873	3	7
Floors in Rooms without Windows	R&M-I	14	5	668	63	1.378	28	139
	R&M-II	15	1	1,269	48	1.710	19	123
	R&M-III	14	7	353	44	1.087	23	82
	Previously Abated	6	<1	339	40	2.553	3	577
	Modern Urban	3	<1	24	1	4.415	<1	44,907
Window Sill	R&M-I	40	10	18,272	460	1.849	237	892
	R&M-II	44	4	16,450	195	1.984	94	405
	R&M-III	54	<1	12,888	26	1.959	15	45
	Previously Abated	26	<1	960	35	2.430	13	100
	Modern Urban	28	1	74	6	1.022	4	10
Upholstery	R&M-I	12	3	29,511	82	2.519	16	404
	R&M-II	9	14	470	60	1.157	25	146
	R&M-III	12	7	243	38	1.219	18	83
	Previously Abated	4	5	200	22	1.813	1	393
	Modern Urban	4	1	8	2	1.020	<1	9
Window Well	R&M-I	35	25	120,549	9,828	1.891	5,034	19,184
	R&M-II	42	<1	704,285	2,122	2.690	664	6,783
	R&M-III	53	1	7,897	164	1.612	102	263
	Previously Abated	26	45	78,092	938	1.964	344	2,559
	Modern Urban	28	7	1,432	154	1.209	81	295

[a] GM values and confidence intervals for floors (rooms with windows), window sills, and window wells were obtained from SAS® PROC MIXED

Table B-3: Descriptive Statistics For Dust Loadings By Surface Type And Study Group At The 24-Month Campaign

Surface Type	Study Group	n	Minimum (mg/ft^2)	Maximum (mg/ft^2)	Geometric Mean[a] (mg/ft^2)	S.D. on log scale	Lower 95% CI for GM (mg/ft^2)	Upper 95% CI for GM (mg/ft^2)
Air Duct	R&M-I	8	2,362	214,902	27,323	1.394	8,519	87,630
	R&M-II	12	3,957	89,758	22,611	0.961	12,278	41,641
	R&M-III	15	78	201,043	15,335	2.094	4,810	48,892
	Previously Abated	9	2,325	90,540	33,929	1.278	12,701	90,637
	Modern Urban	10	1,089	26,995	6,454	1.041	3,065	13,589
Interior Entryway	R&M-I	21	<1	1,698	65	2.258	23	182
	R&M-II	22	6	3,455	183	1.664	88	384
	R&M-III	27	6	2,944	143	1.456	81	225
	Previously Abated	13	6	1,939	95	1.802	32	283
	Modern Urban	14	25	1,922	201	1.387	90	448
Floors in Rooms with Windows	R&M-I	43	2	1,844	88	1.192	60	128
	R&M-II	44	5	922	90	1.114	59	137
	R&M-III	54	8	828	81	1.104	56	119
	Previously Abated	26	11	507	101	0.991	66	155
	Modern Urban	29	15	357	88	0.838	57	134
Floors in Rooms without Windows	R&M-I	14	21	1,021	103	1.117	54	197
	R&M-II	15	6	528	120	1.174	63	230
	R&M-III	14	25	794	83	1.137	43	159
	Previously Abated	6	7	212	67	1.216	19	240
	Modern Urban	3	75	80	77	0.030	72	83
Window Sill	R&M-I	40	3	829	69	1.349	43	109
	R&M-II	44	4	823	67	1.331	43	103
	R&M-III	54	2	1,390	35	1.178	24	50
	Previously Abated	26	8	382	63	1.005	41	97
	Modern Urban	28	3	265	32	0.965	20	52
Upholstery	R&M-I	12	6	8,324	91	1.833	28	290
	R&M-II	9	14	390	105	1.094	45	244
	R&M-III	12	28	463	88	0.859	51	152
	Previously Abated	4	10	142	38	1.178	6	250
	Modern Urban	4	<1	29	8	2.427	<1	385
Window Well	R&M-I	35	6	7,931	663	1.229	429	1,025
	R&M-II	42	<1	18,838	402	1.848	203	796
	R&M-III	53	1	3,359	143	1.619	84	245
	Previously Abated	26	85	12,929	495	1.215	287	853
	Modern Urban	28	14	2,318	388	1.121	220	685

[a] GM values and confidence intervals for floors (rooms with windows), window sills, and window wells were obtained from SAS® PROC MIXED

APPENDIX C

Comprehensive Follow-up Services, According to Diagnostic Blood Lead Levels

Table 4.3 of CDC Guidelines:

"Screening Young Children for Lead Poisoning: Guidance for State and Local Public Health Officials"

November 1997

7. Participate in a follow-up team.

Table 4.3. Comprehensive follow-up services, according to diagnostic* BLL

BLL (μg/dL)	Action
<10	Reassess or rescreen in 1 year. No additional action necessary unless exposure sources change.
10-14	Provide family lead education. Provide follow-up testing. Refer for social services, if necessary.
15-19	Provide family lead education. Provide follow-up testing. Refer for social services, if necessary. If BLLs persist (i.e., 2 venous BLLs in this range at least 3 months apart) or worsen, proceed according to actions for BLLs 20-44.
20-44	Provide coordination of care (case management). Provide clinical management (described in text). Provide environmental investigation. Provide lead-hazard control.
45-69	Within 48 hours, begin coordination of care (case management), clinical management (described in text), environmental investigation, and lead hazard control.
70 or higher	Hospitalize child and begin medical treatment immediately. Begin coordination of care (case management), clinical management (described in text), environmental investigation, and lead-hazard control immediately.

* A diagnostic BLL is the first venous BLL obtained within 6 months of an elevated screening BLL.

APPENDIX D

Dust and Dust Lead
Factor Patterns Across Campaigns

Table D-1: Factor Patterns For The Five Study Groups Across Campaigns

Dust Measure	Surface Type	Initial factor1	Initial factor2	Six-Month factor1	Six-Month factor2	12-Month factor1	12-Month factor2	18-Month factor1	18-Month factor2	24-Month factor1	24-Month factor2	Overall factor1	Overall factor2
Lead Loading	Floor	0.87	0.48	0.71	0.70	0.68	0.73	0.68	0.73	0.78	-0.53	0.83	0.56
	Sill	0.91	-0.11	0.89	-0.24	0.89	-0.19	0.90	-0.28	0.84	-0.05	0.92	-0.18
	Well	0.91	-0.35	0.87	-0.33	0.84	-0.38	0.90	-0.28	0.76	0.60	0.89	-0.33
Lead Concentration	Floor	0.88	0.46	0.74	0.67	0.74	0.67	0.73	0.67	0.84	-0.45	0.82	0.57
	Sill	0.94	-0.10	0.91	-0.26	0.84	-0.32	0.89	-0.31	0.89	-0.05	0.90	-0.20
	Well	0.91	-0.34	0.90	-0.29	0.85	-0.26	0.91	-0.24	0.83	0.52	0.89	-0.32
Dust Loading	Floor	0.76	0.62	0.71	0.70	0.49	0.85	0.55	0.82	0.58	0.78	0.75	0.66
	Sill	0.89	-0.07	0.81	-0.23	0.88	-0.08	0.79	-0.42	0.72	-0.51	0.88	-0.25
	Well	0.81	-0.50	0.79	-0.39	0.80	-0.44	0.85	-0.15	0.80	-0.10	0.86	-0.32

Factor1 and Factor2 are explained in Section 6.3.

Table D-2: Factor Patterns For R&M Groups Across Campaigns

Dust Measure	Surface Type	Campaign													
		Initial		Post-Intervention		Two-Month		Six-Month		12-Month		18-Month		24-Month	
		factor1	factor2	factor1	factor2	factor1	factor2	factor1	factor2	factor1	factor2	factor1	factor2	factor1	factor2
Lead Loading	Floor	0.82	-0.29	0.76	0.61	0.49	0.86	0.58	0.82	0.40	0.91	0.52	0.86	0.66	0.71
	Sill	0.82	-0.27	0.87	-0.07	0.90	-0.13	0.88	-0.30	0.90	-0.13	0.90	-0.28	0.80	-0.10
	Well	0.55	0.83	0.79	-0.51	0.86	-0.36	0.90	-0.23	0.87	-0.29	0.92	-0.20	0.73	-0.53
Lead Concentration	Floor	0.76	-0.47	0.52	0.86	0.57	0.82	0.54	0.84	0.40	0.92	0.52	0.85	0.74	-0.58
	Sill	0.82	-0.14	0.88	-0.19	0.86	-0.30	0.90	-0.22	0.86	-0.22	0.90	-0.28	0.85	-0.03
	Well	0.63	0.76	0.85	-0.32	0.87	-0.25	0.89	-0.29	0.86	-0.21	0.91	-0.21	0.71	0.64
Dust Loading	Floor	0.82	-0.28	0.73	-0.55	0.49	0.85	0.66	0.74	0.38	0.92	0.53	0.84	0.54	0.82
	Sill	0.81	-0.33	0.80	-0.08	0.88	-0.09	0.86	-0.18	0.89	-0.09	0.83	-0.37	0.74	-0.48
	Well	0.65	0.76	0.68	0.69	0.80	-0.43	0.81	-0.41	0.84	-0.32	0.88	-0.16	0.82	-0.11

Factor1 and Factor2 are explained in Section 6.3.

APPENDIX E

Descriptive Statistics for Baseline Blood Lead Concentrations by Group

Table E-1: Descriptive Statistics For Baseline Blood Lead Concentrations By Group

Study Group	N	Minimum (µg/dL)	Maximum (µg/dL)	Geometric Mean[a] (µg/dL)	S.D. on log scale	Lower 95% CI for GM (µg/dL)	Upper 95% CI for GM (µg/dL)
R&M Level I	33	1.8	21.0	8.9	0.617	7.2	11.2
R&M Level II	31	2.6	38.1	13.4	0.487	11.2	16.1
R&M Level III	35	2.7	43.2	14.1	0.556	11.6	17.0
Previously Abated	23	3.7	28.8	12.3	0.588	9.4	16.0
Modern Urban	19	0.9	10.2	3.2	0.493	2.5	4.1

[a] GM values and confidence intervals were obtained from SAS® PROC MIXED

APPENDIX F

Longitudinal Data Analysis:

Model Results

ENVIRONMENTAL MODEL FOR DUST LEAD LOADINGS IN R&M HOUSES
R&M houses reclassified during follow-up based on work performed by owners were removed from model after reclassification

Covariance Parameter Estimates (REML)

Cov Parm	Ratio	Estimate	Std Error	Z	Pr > |Z|
DID	0.65035706	0.11645850	0.02415610	4.82	0.0001
Residual	1.00000000	0.17906855	0.01257680	14.24	0.0001

Model Fitting Information for FACTOR1

Description	Value
Observations	499.0000
Variance Estimate	0.1791
Standard Deviation Estimate	0.4232
REML Log Likelihood	-364.160
Akaike's Information Criterion	-366.160
Schwarz's Bayesian Criterion	-370.323
-2 REML Log Likelihood	728.3201

Solution for Fixed Effects

Parameter	Estimate	Std Error	DDF	T	Pr > |T|	Alpha	Lower	Upper
INTERCEPT	0.30739352	0.12122924	70	2.54	0.0135	0.05	0.0656	0.5492
SPRING	-0.02864649	0.06265043	405	-0.46	0.6477	0.05	-0.1518	0.0945
SUMMER	-0.10809748	0.05451997	405	-1.98	0.0481	0.05	-0.2153	-0.0009
FALL	0.01605530	0.06322863	405	0.25	0.7997	0.05	-0.1082	0.1404
CAMPAIGN 00	0.97780221	0.12997171	405	7.52	0.0001	0.05	0.7223	1.2333
CAMPAIGN 02	0.01308334	0.13260233	405	0.10	0.9215	0.05	-0.2476	0.2738
CAMPAIGN 06	0.15315823	0.12810019	405	1.20	0.2325	0.05	-0.0987	0.4050
CAMPAIGN 12	0.15713164	0.12934448	405	1.21	0.2251	0.05	-0.0971	0.4114
CAMPAIGN 18	0.02303655	0.12858495	405	0.18	0.8579	0.05	-0.2297	0.2758
CAMPAIGN 24	-0.02651302	0.13129992	405	-0.20	0.8401	0.05	-0.2846	0.2316
CAMPAIGN PI	0.00000000	.	.	.	.	.	.	.
GROUP Level3	-1.58978450	0.15626599	405	-10.17	0.0001	0.05	-1.8970	-1.2826
GROUP Level2	-0.67529831	0.16238958	405	-4.16	0.0001	0.05	-0.9945	-0.3561
GROUP Level1	0.00000000	.	.	.	.	.	.	.
GROUP*CAMPAIGN Level3 00	2.38254281	0.17534482	405	13.59	0.0001	0.05	2.0378	2.7272
GROUP*CAMPAIGN Level3 02	0.67702805	0.17872126	405	3.79	0.0002	0.05	0.3257	1.0284
GROUP*CAMPAIGN Level3 06	0.41952623	0.17109298	405	2.45	0.0146	0.05	0.0832	0.7559
GROUP*CAMPAIGN Level3 12	0.33268361	0.17293946	405	1.92	0.0551	0.05	-0.0073	0.6727
GROUP*CAMPAIGN Level3 18	0.48688946	0.17118421	405	2.84	0.0047	0.05	0.1504	0.8234
GROUP*CAMPAIGN Level3 24	0.48041230	0.17419123	405	2.76	0.0061	0.05	0.1380	0.8228
GROUP*CAMPAIGN Level3 PI	0.00000000	.	.	.	.	.	.	.
GROUP*CAMPAIGN Level2 00	0.96188601	0.18010574	405	5.34	0.0001	0.05	0.6078	1.3159
GROUP*CAMPAIGN Level2 02	0.50483020	0.18253201	405	2.77	0.0059	0.05	0.1460	0.8637
GROUP*CAMPAIGN Level2 06	0.16212016	0.17885424	405	0.91	0.3652	0.05	-0.1895	0.5137
GROUP*CAMPAIGN Level2 12	0.21371154	0.17983794	405	1.19	0.2354	0.05	-0.1398	0.5672
GROUP*CAMPAIGN Level2 18	0.15634973	0.17872342	405	0.87	0.3822	0.05	-0.1950	0.5077
GROUP*CAMPAIGN Level2 24	0.30063258	0.18254454	405	1.65	0.1004	0.05	-0.0582	0.6595
GROUP*CAMPAIGN Level2 PI	0.00000000	.	.	.	.	.	.	.
GROUP*CAMPAIGN Level1 00	0.00000000	.	.	.	.	.	.	.
GROUP*CAMPAIGN Level1 02	0.00000000	.	.	.	.	.	.	.
GROUP*CAMPAIGN Level1 06	0.00000000	.	.	.	.	.	.	.
GROUP*CAMPAIGN Level1 12	0.00000000	.	.	.	.	.	.	.
GROUP*CAMPAIGN Level1 18	0.00000000	.	.	.	.	.	.	.
GROUP*CAMPAIGN Level1 24	0.00000000	.	.	.	.	.	.	.
GROUP*CAMPAIGN Level1 PI	0.00000000	.	.	.	.	.	.	.

Tests of Fixed Effects

Source	NDF	DDF	Type III F	Pr > F
SPRING	1	405	0.21	0.6477
SUMMER	1	405	3.93	0.0481
FALL	1	405	0.06	0.7997
CAMPAIGN	6	405	193.86	0.0001
GROUP	2	405	36.84	0.0001
GROUP*CAMPAIGN	12	405	20.54	0.0001

ENVIRONMENTAL MODEL FOR DUST LEAD CONCENTRATIONS IN R&M HOUSES
R&M houses reclassified during follow-up based on work performed by owners were excluded from analysis after reclassification

Covariance Parameter Estimates (REML)

Cov Parm	Ratio	Estimate	Std Error	Z	Pr > |Z|
DID	1.26112462	0.28155530	0.05324388	5.29	0.0001
Residual	1.00000000	0.22325732	0.01568953	14.23	0.0001

Model Fitting Information for FACTOR1

Description	Value
Observations	499.0000
Variance Estimate	0.2233
Standard Deviation Estimate	0.4725
REML Log Likelihood	-436.427
Akaike's Information Criterion	-438.427
Schwarz's Bayesian Criterion	-442.590
-2 REML Log Likelihood	872.8536

Solution for Fixed Effects

Parameter	Estimate	Std Error	DDF	T	Pr > |T|	Alpha	Lower	Upper
INTERCEPT	0.85974692	0.15664009	70	5.49	0.0001	0.05	0.5473	1.1722
SPRING	0.02006761	0.07066442	405	0.28	0.7766	0.05	-0.1188	0.1590
SUMMER	0.04198899	0.06102211	405	0.69	0.4918	0.05	-0.0780	0.1619
FALL	0.11396211	0.07134298	405	1.60	0.1110	0.05	-0.0263	0.2542
GROUP Level3	-1.48667959	0.20378655	405	-7.30	0.0001	0.05	-1.8873	-1.0861
GROUP Level2	-0.18154263	0.21214865	405	-0.86	0.3927	0.05	-0.5986	0.2355
GROUP Level1	0.00000000	.	.	.	.	.	.	.
CAMPAIGN 00	-0.08995186	0.14517168	405	-0.62	0.5359	0.05	-0.3753	0.1954
CAMPAIGN 02	-0.37436656	0.14818031	405	-2.53	0.0119	0.05	-0.6657	-0.0831
CAMPAIGN 06	-0.43291457	0.14303842	405	-3.03	0.0026	0.05	-0.7141	-0.1517
CAMPAIGN 12	-0.38614450	0.14445855	405	-2.67	0.0078	0.05	-0.6701	-0.1022
CAMPAIGN 18	-0.54970012	0.14358241	405	-3.83	0.0001	0.05	-0.8320	-0.2674
CAMPAIGN 24	-0.58619045	0.14666618	405	-4.00	0.0001	0.05	-0.8745	-0.2979
CAMPAIGN PI	0.00000000	.	.	.	.	.	.	.
GROUP*CAMPAIGN Level3 00	1.78186311	0.19592427	405	9.09	0.0001	0.05	1.3967	2.1670
GROUP*CAMPAIGN Level3 02	0.24938034	0.19972660	405	1.25	0.2125	0.05	-0.1432	0.6420
GROUP*CAMPAIGN Level3 06	0.18118924	0.19105443	405	0.95	0.3435	0.05	-0.1944	0.5568
GROUP*CAMPAIGN Level3 12	-0.02126212	0.19314650	405	-0.11	0.9124	0.05	-0.4010	0.3584
GROUP*CAMPAIGN Level3 18	-0.01317041	0.19114856	405	-0.07	0.9451	0.05	-0.3889	0.3626
GROUP*CAMPAIGN Level3 24	0.18364589	0.19455764	405	0.94	0.3458	0.05	-0.1988	0.5661
GROUP*CAMPAIGN Level3 PI	0.00000000	.	.	.	.	.	.	.
GROUP*CAMPAIGN Level2 00	0.30828309	0.20114025	405	1.53	0.1261	0.05	-0.0871	0.7037
GROUP*CAMPAIGN Level2 02	-0.09987854	0.20386336	405	-0.49	0.6244	0.05	-0.5006	0.3009
GROUP*CAMPAIGN Level2 06	-0.25360922	0.19971043	405	-1.27	0.2049	0.05	-0.6462	0.1390
GROUP*CAMPAIGN Level2 12	-0.51711112	0.20083091	405	-2.57	0.0104	0.05	-0.9119	-0.1223
GROUP*CAMPAIGN Level2 18	-0.35417972	0.19956221	405	-1.77	0.0767	0.05	-0.7465	0.0381
GROUP*CAMPAIGN Level2 24	-0.32587043	0.20388771	405	-1.60	0.1108	0.05	-0.7267	0.0749
GROUP*CAMPAIGN Level2 PI	0.00000000	.	.	.	.	.	.	.
GROUP*CAMPAIGN Level1 00	0.00000000	.	.	.	.	.	.	.
GROUP*CAMPAIGN Level1 02	0.00000000	.	.	.	.	.	.	.
GROUP*CAMPAIGN Level1 06	0.00000000	.	.	.	.	.	.	.
GROUP*CAMPAIGN Level1 12	0.00000000	.	.	.	.	.	.	.
GROUP*CAMPAIGN Level1 18	0.00000000	.	.	.	.	.	.	.
GROUP*CAMPAIGN Level1 24	0.00000000	.	.	.	.	.	.	.
GROUP*CAMPAIGN Level1 PI	0.00000000	.	.	.	.	.	.	.

Tests of Fixed Effects

Source	NDF	DDF	Type III F	Pr > F
SPRING	1	405	0.08	0.7766
SUMMER	1	405	0.47	0.4918
FALL	1	405	2.55	0.1110
GROUP	2	405	27.87	0.0001
CAMPAIGN	6	405	65.43	0.0001
GROUP*CAMPAIGN	12	405	12.39	0.0001

ENVIRONMENTAL MODEL FOR DUST LOADINGS IN R&M HOUSES
R&M houses reclassified during follow-up based on work performed by owners were excluded from analysis after reclassification

Covariance Parameter Estimates (REML)

Cov Parm	Ratio	Estimate	Std Error	Z	Pr > |Z|
DID	0.27249833	0.06414238	0.01687477	3.80	0.0001
Residual	1.00000000	0.23538633	0.01653703	14.23	0.0001

Model Fitting Information for FACTOR1

Description	Value
Observations	499.0000
Variance Estimate	0.2354
Standard Deviation Estimate	0.4852
REML Log Likelihood	-406.665
Akaike's Information Criterion	-408.665
Schwarz's Bayesian Criterion	-412.829
-2 REML Log Likelihood	813.3309

Solution for Fixed Effects

Parameter	Estimate	Std Error	DDF	T	Pr > |T|	Alpha	Lower	Upper
INTERCEPT	-0.31766399	0.12347123	70	-2.57	0.0122	0.05	-0.5639	-0.0714
SPRING	-0.04480998	0.07041009	405	-0.64	0.5249	0.05	-0.1832	0.0936
SUMMER	-0.20140588	0.06220254	405	-3.24	0.0013	0.05	-0.3237	-0.0791
FALL	-0.06239404	0.07101297	405	-0.88	0.3801	0.05	-0.2020	0.0772
CAMPAIGN 00	1.63179826	0.14892080	405	10.96	0.0001	0.05	1.3390	1.9246
CAMPAIGN 02	0.40136365	0.15179711	405	2.64	0.0085	0.05	0.1030	0.6998
CAMPAIGN 06	0.67091348	0.14686253	405	4.57	0.0001	0.05	0.3822	0.9596
CAMPAIGN 12	0.64859926	0.14822922	405	4.38	0.0001	0.05	0.3572	0.9400
CAMPAIGN 18	0.59214228	0.14741267	405	4.02	0.0001	0.05	0.3024	0.8819
CAMPAIGN 24	0.54680903	0.15042075	405	3.64	0.0003	0.05	0.2511	0.8425
CAMPAIGN PI	0.00000000	.	.	.	.	.	.	.
GROUP Level3	-1.17506766	0.15763128	405	-7.45	0.0001	0.05	-1.4849	-0.8652
GROUP Level2	-0.93969372	0.16355112	405	-5.75	0.0001	0.05	-1.2612	-0.6182
GROUP Level1	0.00000000	.	.	.	.	.	.	.
GROUP*CAMPAIGN Level3 00	2.08035406	0.20076783	405	10.36	0.0001	0.05	1.6857	2.4750
GROUP*CAMPAIGN Level3 02	0.82467555	0.20457169	405	4.03	0.0001	0.05	0.4225	1.2268
GROUP*CAMPAIGN Level3 06	0.48130559	0.19613377	405	2.45	0.0145	0.05	0.0957	0.8669
GROUP*CAMPAIGN Level3 12	0.52839768	0.19818986	405	2.67	0.0080	0.05	0.1388	0.9180
GROUP*CAMPAIGN Level3 18	0.74992200	0.19625322	405	3.82	0.0002	0.05	0.3641	1.1357
GROUP*CAMPAIGN Level3 24	0.56755647	0.19959681	405	2.84	0.0047	0.05	0.1752	0.9599
GROUP*CAMPAIGN Level3 PI	0.00000000	.	.	.	.	.	.	.
GROUP*CAMPAIGN Level2 00	1.22490602	0.20642219	405	5.93	0.0001	0.05	0.8191	1.6307
GROUP*CAMPAIGN Level2 02	0.88208856	0.20917238	405	4.22	0.0001	0.05	0.4709	1.2933
GROUP*CAMPAIGN Level2 06	0.51925169	0.20505191	405	2.53	0.0117	0.05	0.1162	0.9224
GROUP*CAMPAIGN Level2 12	0.84019990	0.20613645	405	4.08	0.0001	0.05	0.4350	1.2454
GROUP*CAMPAIGN Level2 18	0.60337479	0.20490617	405	2.94	0.0034	0.05	0.2006	1.0062
GROUP*CAMPAIGN Level2 24	0.78770441	0.20916800	405	3.77	0.0002	0.05	0.3765	1.1989
GROUP*CAMPAIGN Level2 PI	0.00000000	.	.	.	.	.	.	.
GROUP*CAMPAIGN Level1 00	0.00000000	.	.	.	.	.	.	.
GROUP*CAMPAIGN Level1 02	0.00000000	.	.	.	.	.	.	.
GROUP*CAMPAIGN Level1 06	0.00000000	.	.	.	.	.	.	.
GROUP*CAMPAIGN Level1 12	0.00000000	.	.	.	.	.	.	.
GROUP*CAMPAIGN Level1 18	0.00000000	.	.	.	.	.	.	.
GROUP*CAMPAIGN Level1 24	0.00000000	.	.	.	.	.	.	.
GROUP*CAMPAIGN Level1 PI	0.00000000	.	.	.	.	.	.	.

Tests of Fixed Effects

Source	NDF	DDF	Type III F	Pr > F
SPRING	1	405	0.41	0.5249
SUMMER	1	405	10.48	0.0013
FALL	1	405	0.77	0.3801
CAMPAIGN	6	405	195.09	0.0001
GROUP	2	405	11.35	0.0001
GROUP*CAMPAIGN	12	405	11.66	0.0001

ENVIRONMENTAL MODEL FOR DUST LEAD LOADINGS IN R&M AND CONTROL HOUSES

R&M houses reclassified during follow-up based on work performed by owners were excluded from analysis after reclassification

Covariance Parameter Estimates (REML)

Cov Parm	Ratio	Estimate	Std Error	Z	Pr > |Z|
DID	1.00774647	0.12442621	0.02245993	5.54	0.0001
Residual	1.00000000	0.12346976	0.00920947	13.41	0.0001

Model Fitting Information for FACTOR1

Description	Value
Observations	489.0000
Variance Estimate	0.1235
Standard Deviation Estimate	0.3514
REML Log Likelihood	-299.112
Akaike's Information Criterion	-301.112
Schwarz's Bayesian Criterion	-305.245
-2 REML Log Likelihood	598.2235

Solution for Fixed Effects

Parameter	Estimate	Std Error	DDF	T	Pr > |T|	Alpha	Lower	Upper
INTERCEPT	0.16330482	0.15282757	97	1.07	0.2879	0.05	-0.1400	0.4666
SPRING	-0.03692075	0.05250732	364	-0.70	0.4824	0.05	-0.1402	0.0663
SUMMER	-0.05933019	0.04707857	364	-1.26	0.2084	0.05	-0.1519	0.0332
FALL	-0.04278111	0.05853635	364	-0.73	0.4653	0.05	-0.1579	0.0723
CAMPAIGN 24	-0.39515960	0.14989117	364	-2.64	0.0087	0.05	-0.6899	-0.1004
CAMPAIGN 18	-0.42929113	0.15295387	364	-2.81	0.0053	0.05	-0.7301	-0.1285
CAMPAIGN 12	-0.21389997	0.14991805	364	-1.43	0.1545	0.05	-0.5087	0.0809
CAMPAIGN 06	-0.24237874	0.15496474	364	-1.56	0.1187	0.05	-0.5471	0.0624
CAMPAIGN 00	0.00000000	.	.	.	.	.	.	.
GROUP Modern	-1.13927405	0.19768538	364	-5.76	0.0001	0.05	-1.5280	-0.7505
GROUP Level3	1.90735386	0.17780753	364	10.73	0.0001	0.05	1.5577	2.2570
GROUP Level2	1.42308294	0.18353187	364	7.75	0.0001	0.05	1.0622	1.7840
GROUP Level1	1.15501038	0.18537697	364	6.23	0.0001	0.05	0.7905	1.5196
GROUP Abated	0.00000000	.	.	.	.	.	.	.
GROUP*CAMPAIGN Modern 24	-0.09545246	0.19922033	364	-0.48	0.6321	0.05	-0.4872	0.2963
GROUP*CAMPAIGN Modern 18	0.15939816	0.20044952	364	0.80	0.4270	0.05	-0.2348	0.5536
GROUP*CAMPAIGN Modern 12	-0.02900558	0.19759031	364	-0.15	0.8834	0.05	-0.4176	0.3596
GROUP*CAMPAIGN Modern 06	0.11228796	0.19736223	364	0.57	0.5697	0.05	-0.2758	0.5004
GROUP*CAMPAIGN Modern 00	0.00000000	.	.	.	.	.	.	.
GROUP*CAMPAIGN Level3 24	-2.25155701	0.17737897	364	-12.69	0.0001	0.05	-2.6004	-1.9027
GROUP*CAMPAIGN Level3 18	-2.16879573	0.17962213	364	-12.07	0.0001	0.05	-2.5220	-1.8156
GROUP*CAMPAIGN Level3 12	-2.42586260	0.17809903	364	-13.62	0.0001	0.05	-2.7761	-2.0756
GROUP*CAMPAIGN Level3 06	-2.30194880	0.18004880	364	-12.79	0.0001	0.05	-2.6560	-1.9479
GROUP*CAMPAIGN Level3 00	0.00000000	.	.	.	.	.	.	.
GROUP*CAMPAIGN Level2 24	-1.13461783	0.18317600	364	-6.19	0.0001	0.05	-1.4948	-0.7744
GROUP*CAMPAIGN Level2 18	-1.18064606	0.18470749	364	-6.39	0.0001	0.05	-1.5439	-0.8174
GROUP*CAMPAIGN Level2 12	-1.22959481	0.18221211	364	-6.75	0.0001	0.05	-1.5879	-0.8713
GROUP*CAMPAIGN Level2 06	-1.25065271	0.18593763	364	-6.73	0.0001	0.05	-1.6163	-0.8850
GROUP*CAMPAIGN Level2 00	0.00000000	.	.	.	.	.	.	.
GROUP*CAMPAIGN Level1 24	-0.52386927	0.18691328	364	-2.80	0.0053	0.05	-0.8914	-0.1563
GROUP*CAMPAIGN Level1 18	-0.43600424	0.18674536	364	-2.33	0.0201	0.05	-0.8032	-0.0688
GROUP*CAMPAIGN Level1 12	-0.54132288	0.18545324	364	-2.92	0.0037	0.05	-0.9060	-0.1766
GROUP*CAMPAIGN Level1 06	-0.50761259	0.18796581	364	-2.70	0.0072	0.05	-0.8772	-0.1380
GROUP*CAMPAIGN Level1 00	0.00000000	.	.	.	.	.	.	.
GROUP*CAMPAIGN Abated 24	0.00000000	.	.	.	.	.	.	.
GROUP*CAMPAIGN Abated 18	0.00000000	.	.	.	.	.	.	.
GROUP*CAMPAIGN Abated 12	0.00000000	.	.	.	.	.	.	.
GROUP*CAMPAIGN Abated 06	0.00000000	.	.	.	.	.	.	.
GROUP*CAMPAIGN Abated 00	0.00000000	.	.	.	.	.	.	.

Tests of Fixed Effects

Source	NDF	DDF	Type III F	Pr > F
SPRING	1	364	0.49	0.4824
SUMMER	1	364	1.59	0.2084
FALL	1	364	0.53	0.4653
CAMPAIGN	4	364	169.54	0.0001
GROUP	4	364	56.84	0.0001
GROUP*CAMPAIGN	16	364	31.48	0.0001

ENVIRONMENTAL MODEL FOR DUST LEAD CONCENTRATIONS IN R&M AND CONTROL HOUSES

R&M houses reclassified during follow-up based on work performed by owners were excluded from analysis after reclassification

Covariance Parameter Estimates (REML)

Cov Parm	Ratio	Estimate	Std Error	Z	Pr > |Z|
DID	1.35960409	0.18684398	0.03183210	5.87	0.0001
Residual	1.00000000	0.13742529	0.01022755	13.44	0.0001

Model Fitting Information for FACTOR1

Description	Value
Observations	489.0000
Variance Estimate	0.1374
Standard Deviation Estimate	0.3707
REML Log Likelihood	-335.988
Akaike's Information Criterion	-337.988
Schwarz's Bayesian Criterion	-342.122
-2 REML Log Likelihood	671.9764

Solution for Fixed Effects

Parameter	Estimate	Std Error	DDF	T	Pr > |T|	Alpha	Lower	Upper
INTERCEPT	-0.01785020	0.17438384	97	-0.10	0.9187	0.05	-0.3640	0.3283
SPRING	0.01905647	0.05593016	364	0.34	0.7335	0.05	-0.0909	0.1290
SUMMER	0.08744812	0.04980344	364	1.76	0.0800	0.05	-0.0105	0.1854
FALL	0.08354389	0.06234936	364	1.34	0.1811	0.05	-0.0391	0.2062
GROUP Modern	-1.53494795	0.22608935	364	-6.79	0.0001	0.05	-1.9796	-1.0903
GROUP Level3	1.28947508	0.20296109	364	6.35	0.0001	0.05	0.8904	1.6886
GROUP Level2	1.10781912	0.20974390	364	5.28	0.0001	0.05	0.6954	1.5203
GROUP Level1	0.98279819	0.21177162	364	4.64	0.0001	0.05	0.5663	1.3992
GROUP Abated	0.00000000	.	.	.	.	.	.	.
CAMPAIGN 24	-0.28942552	0.15813575	364	-1.83	0.0680	0.05	-0.6004	0.0215
CAMPAIGN 18	-0.25349905	0.16139171	364	-1.57	0.1171	0.05	-0.5709	0.0639
CAMPAIGN 12	-0.03064815	0.15816549	364	-0.19	0.8465	0.05	-0.3417	0.2804
CAMPAIGN 06	-0.24873338	0.16351339	364	-1.52	0.1291	0.05	-0.5703	0.0728
CAMPAIGN 00	0.00000000	.	.	.	.	.	.	.
GROUP*CAMPAIGN Modern 24	0.14208682	0.21020912	364	0.68	0.4995	0.05	-0.2713	0.5555
GROUP*CAMPAIGN Modern 18	0.19127335	0.21154373	364	0.90	0.3665	0.05	-0.2247	0.6073
GROUP*CAMPAIGN Modern 12	0.08717275	0.20846517	364	0.42	0.6761	0.05	-0.3228	0.4971
GROUP*CAMPAIGN Modern 06	0.26206979	0.20822022	364	1.26	0.2090	0.05	-0.1474	0.6715
GROUP*CAMPAIGN Modern 00	0.00000000	.	.	.	.	.	.	.
GROUP*CAMPAIGN Level3 24	-1.37729492	0.18727816	364	-7.35	0.0001	0.05	-1.7456	-1.0090
GROUP*CAMPAIGN Level3 18	-1.55672384	0.18956234	364	-8.21	0.0001	0.05	-1.9295	-1.1839
GROUP*CAMPAIGN Level3 12	-1.67443819	0.18791441	364	-8.91	0.0001	0.05	-2.0440	-1.3049
GROUP*CAMPAIGN Level3 06	-1.30920377	0.18997338	364	-6.89	0.0001	0.05	-1.6828	-0.9356
GROUP*CAMPAIGN Level3 00	0.00000000	.	.	.	.	.	.	.
GROUP*CAMPAIGN Level2 24	-0.63029574	0.19326062	364	-3.26	0.0012	0.05	-1.0103	-0.2502
GROUP*CAMPAIGN Level2 18	-0.66599849	0.19489239	364	-3.42	0.0007	0.05	-1.0493	-0.2827
GROUP*CAMPAIGN Level2 12	-0.89066575	0.19223464	364	-4.63	0.0001	0.05	-1.2687	-0.5126
GROUP*CAMPAIGN Level2 06	-0.49463538	0.19618408	364	-2.52	0.0121	0.05	-0.8804	-0.1088
GROUP*CAMPAIGN Level2 00	0.00000000	.	.	.	.	.	.	.
GROUP*CAMPAIGN Level1 24	-0.11368599	0.19723602	364	-0.58	0.5647	0.05	-0.5016	0.2742
GROUP*CAMPAIGN Level1 18	-0.11420897	0.19703795	364	-0.58	0.5625	0.05	-0.5017	0.2733
GROUP*CAMPAIGN Level1 12	-0.21306015	0.19568142	364	-1.09	0.2770	0.05	-0.5979	0.1717
GROUP*CAMPAIGN Level1 06	-0.02379259	0.19833831	364	-0.12	0.9046	0.05	-0.4138	0.3662
GROUP*CAMPAIGN Level1 00	0.00000000	.	.	.	.	.	.	.
GROUP*CAMPAIGN Abated 24	0.00000000	.	.	.	.	.	.	.
GROUP*CAMPAIGN Abated 18	0.00000000	.	.	.	.	.	.	.
GROUP*CAMPAIGN Abated 12	0.00000000	.	.	.	.	.	.	.
GROUP*CAMPAIGN Abated 06	0.00000000	.	.	.	.	.	.	.
GROUP*CAMPAIGN Abated 00	0.00000000	.	.	.	.	.	.	.

Tests of Fixed Effects

Source	NDF	DDF	Type III F	Pr > F
SPRING	1	364	0.12	0.7335
SUMMER	1	364	3.08	0.0800
FALL	1	364	1.80	0.1811
GROUP	4	364	60.37	0.0001
CAMPAIGN	4	364	49.27	0.0001
GROUP*CAMPAIGN	16	364	14.48	0.0001

ENVIRONMENTAL MODEL FOR DUST LOADINGS IN R&M AND CONTROL HOUSES
R&M houses reclassified during follow-up based on work performed by owners were excluded from analysis after reclassification

Covariance Parameter Estimates (REML)

Cov Parm	Ratio	Estimate	Std Error	Z	Pr > |Z|
DID	0.70876320	0.17206344	0.03289885	5.23	0.0001
Residual	1.00000000	0.24276577	0.01802994	13.46	0.0001

Model Fitting Information for FACTOR1

Description	Value
Observations	489.0000
Variance Estimate	0.2428
Standard Deviation Estimate	0.4927
REML Log Likelihood	-441.436
Akaike's Information Criterion	-443.436
Schwarz's Bayesian Criterion	-447.569
-2 REML Log Likelihood	882.8717

Solution for Fixed Effects

Parameter	Estimate	Std Error	DDF	T	Pr > |T|	Alpha	Lower	Upper
INTERCEPT	0.31973489	0.19819804	97	1.61	0.1099	0.05	-0.0736	0.7131
SPRING	-0.09081225	0.07265914	364	-1.25	0.2122	0.05	-0.2337	0.0521
SUMMER	-0.22764620	0.06576650	364	-3.46	0.0006	0.05	-0.3570	-0.0983
FALL	-0.18710064	0.08100094	364	-2.31	0.0215	0.05	-0.3464	-0.0278
CAMPAIGN 24	-0.37837532	0.21017844	364	-1.80	0.0726	0.05	-0.7917	0.0349
CAMPAIGN 18	-0.50354362	0.21442754	364	-2.35	0.0194	0.05	-0.9252	-0.0819
CAMPAIGN 12	-0.36115831	0.21021365	364	-1.72	0.0866	0.05	-0.7745	0.0522
CAMPAIGN 06	-0.14468163	0.21724566	364	-0.67	0.5058	0.05	-0.5719	0.2825
CAMPAIGN 00	0.00000000	.	.	.	.	.	.	.
GROUP Modern	-0.16461245	0.25573384	364	-0.64	0.5202	0.05	-0.6675	0.3383
GROUP Level3	2.02512184	0.23047879	364	8.79	0.0001	0.05	1.5719	2.4784
GROUP Level2	1.32701873	0.23762869	364	5.58	0.0001	0.05	0.8597	1.7943
GROUP Level1	0.99915532	0.24012126	364	4.16	0.0001	0.05	0.5270	1.4714
GROUP Abated	0.00000000	.	.	.	.	.	.	.
GROUP*CAMPAIGN Modern 24	-0.35538582	0.27929181	364	-1.27	0.2040	0.05	-0.9046	0.1938
GROUP*CAMPAIGN Modern 18	0.07315355	0.28094808	364	0.26	0.7947	0.05	-0.4793	0.6256
GROUP*CAMPAIGN Modern 12	-0.17708875	0.27705062	364	-0.64	0.5231	0.05	-0.7219	0.3677
GROUP*CAMPAIGN Modern 06	-0.13307741	0.27673851	364	-0.48	0.6309	0.05	-0.6773	0.4111
GROUP*CAMPAIGN Modern 00	0.00000000	.	.	.	.	.	.	.
GROUP*CAMPAIGN Level3 24	-2.60061573	0.24849655	364	-10.47	0.0001	0.05	-3.0893	-2.1119
GROUP*CAMPAIGN Level3 18	-2.18872759	0.25175931	364	-8.69	0.0001	0.05	-2.6838	-1.6936
GROUP*CAMPAIGN Level3 12	-2.54695953	0.24969668	364	-10.20	0.0001	0.05	-3.0380	-2.0559
GROUP*CAMPAIGN Level3 06	-2.77744988	0.25242664	364	-11.00	0.0001	0.05	-3.2738	-2.2811
GROUP*CAMPAIGN Level3 00	0.00000000	.	.	.	.	.	.	.
GROUP*CAMPAIGN Level2 24	-1.38216179	0.25683330	364	-5.38	0.0001	0.05	-1.8872	-0.8771
GROUP*CAMPAIGN Level2 18	-1.40501986	0.25895224	364	-5.43	0.0001	0.05	-1.9143	-0.8958
GROUP*CAMPAIGN Level2 12	-1.22265537	0.25549877	364	-4.79	0.0001	0.05	-1.7251	-0.7202
GROUP*CAMPAIGN Level2 06	-1.77648512	0.26068716	364	-6.81	0.0001	0.05	-2.2891	-1.2638
GROUP*CAMPAIGN Level2 00	0.00000000	.	.	.	.	.	.	.
GROUP*CAMPAIGN Level1 24	-0.87899289	0.26201374	364	-3.35	0.0009	0.05	-1.3942	-0.3637
GROUP*CAMPAIGN Level1 18	-0.69572940	0.26181676	364	-2.66	0.0082	0.05	-1.2106	-0.1809
GROUP*CAMPAIGN Level1 12	-0.78717389	0.25999317	364	-3.03	0.0026	0.05	-1.2985	-0.2759
GROUP*CAMPAIGN Level1 06	-0.96576748	0.26350483	364	-3.67	0.0003	0.05	-1.4840	-0.4476
GROUP*CAMPAIGN Level1 00	0.00000000	.	.	.	.	.	.	.
GROUP*CAMPAIGN Abated 24	0.00000000	.	.	.	.	.	.	.
GROUP*CAMPAIGN Abated 18	0.00000000	.	.	.	.	.	.	.
GROUP*CAMPAIGN Abated 12	0.00000000	.	.	.	.	.	.	.
GROUP*CAMPAIGN Abated 06	0.00000000	.	.	.	.	.	.	.
GROUP*CAMPAIGN Abated 00	0.00000000	.	.	.	.	.	.	.

Tests of Fixed Effects

Source	NDF	DDF	Type III F	Pr > F
SPRING	1	364	1.56	0.2122
SUMMER	1	364	11.98	0.0006
FALL	1	364	5.34	0.0215
CAMPAIGN	4	364	124.23	0.0001
GROUP	4	364	4.24	0.0023
GROUP*CAMPAIGN	16	364	18.07	0.0001

EXPOSURE MODEL FOR DUST LEAD LOADINGS IN R&M HOUSES
Excluding Initial Campaign Observations for Vacant Houses

Covariance Parameter Estimates (REML)

Cov Parm	Ratio	Estimate	Std Error	Z	Pr > |Z|
DID	1.82577589	0.11157194	0.03986668	2.80	0.0051
CHILDNUM(DID)	1.12254653	0.06859806	0.02663840	2.58	0.0100
Residual	1.00000000	0.06110933	0.00504897	12.10	0.0001

Model Fitting Information for LNBLOOD

Description	Value
Observations	401.0000
Variance Estimate	0.0611
Standard Deviation Estimate	0.2472
REML Log Likelihood	-156.217
Akaike's Information Criterion	-159.217
Schwarz's Bayesian Criterion	-165.167
-2 REML Log Likelihood	312.4347

Solution for Fixed Effects

Parameter	Estimate	Std Error	DDF	T	Pr > |T|	Alpha	Lower	Upper
INTERCEPT	1.75853992	0.12545929	23	14.02	0.0001	0.05	1.4990	2.0181
FACTOR1	0.01117628	0.03502653	293	0.32	0.7499	0.05	-0.0578	0.0801
FACTOR2	0.00888484	0.01996027	293	0.45	0.6566	0.05	-0.0304	0.0482
AGE	0.02869445	0.00531136	293	5.40	0.0001	0.05	0.0182	0.0391
AGESQ	-0.00025589	0.00005399	293	-4.74	0.0001	0.05	-0.0004	-0.0001
SUMMER	0.16040071	0.03382572	293	4.74	0.0001	0.05	0.0938	0.2270
CAMPAIGN 24	-0.29063090	0.11094358	293	-2.62	0.0093	0.05	-0.5090	-0.0723
CAMPAIGN 18	-0.22054847	0.09718729	293	-2.27	0.0240	0.05	-0.4118	-0.0293
CAMPAIGN 12	-0.12955956	0.08440263	293	-1.54	0.1259	0.05	-0.2957	0.0366
CAMPAIGN 6	-0.02004795	0.07230434	293	-0.28	0.7818	0.05	-0.1623	0.1223
CAMPAIGN 2	0.01628525	0.06634554	293	0.25	0.8063	0.05	-0.1143	0.1469
CAMPAIGN 0	0.00000000	.	.	.	.	.	.	.

Tests of Fixed Effects

Source	NDF	DDF	Type III F	Pr > F
FACTOR1	1	293	0.10	0.7499
FACTOR2	1	293	0.20	0.6566
AGE	1	293	29.19	0.0001
AGESQ	1	293	22.47	0.0001
SUMMER	1	293	22.49	0.0001
CAMPAIGN	5	293	4.17	0.0011

EXPOSURE MODEL FOR DUST LEAD CONCENTRATIONS IN R&M HOUSES
Excluding Initial Campaign Observations for Vacant Houses

Covariance Parameter Estimates (REML)

Cov Parm	Ratio	Estimate	Std Error	Z	Pr > |Z|
DID	1.73745319	0.10661545	0.03947955	2.70	0.0069
CHILDNUM(DID)	1.12680951	0.06914448	0.02706239	2.56	0.0106
Residual	1.00000000	0.06136306	0.00505886	12.13	0.0001

Model Fitting Information for LNBLOOD

Description	Value
Observations	401.0000
Variance Estimate	0.0614
Standard Deviation Estimate	0.2477
REML Log Likelihood	-156.295
Akaike's Information Criterion	-159.295
Schwarz's Bayesian Criterion	-165.244
-2 REML Log Likelihood	312.5892

Solution for Fixed Effects

Parameter	Estimate	Std Error	DDF	T	Pr > |T|	Alpha	Lower	Upper
INTERCEPT	1.76984050	0.12117512	23	14.61	0.0001	0.05	1.5192	2.0205
FACTOR1	-0.00901500	0.02803285	293	-0.32	0.7480	0.05	-0.0642	0.0462
FACTOR2	0.01631496	0.01874556	293	0.87	0.3848	0.05	-0.0206	0.0532
AGE	0.02853510	0.00531188	293	5.37	0.0001	0.05	0.0181	0.0390
AGESQ	-0.00025407	0.00005405	293	-4.70	0.0001	0.05	-0.0004	-0.0001
SUMMER	0.16055360	0.03348302	293	4.80	0.0001	0.05	0.0947	0.2265
CAMPAIGN 24	-0.30703391	0.10494726	293	-2.93	0.0037	0.05	-0.5136	-0.1005
CAMPAIGN 18	-0.23496423	0.09058217	293	-2.59	0.0100	0.05	-0.4132	-0.0567
CAMPAIGN 12	-0.14050783	0.07680271	293	-1.83	0.0683	0.05	-0.2917	0.0106
CAMPAIGN 6	-0.03157916	0.06328316	293	-0.50	0.6181	0.05	-0.1561	0.0930
CAMPAIGN 2	0.00610646	0.05603285	293	0.11	0.9133	0.05	-0.1042	0.1164
CAMPAIGN 0	0.00000000	.	.	.	.	.	.	.

Tests of Fixed Effects

Source	NDF	DDF	Type III F	Pr > F
FACTOR1	1	293	0.10	0.7480
FACTOR2	1	293	0.76	0.3848
AGE	1	293	28.86	0.0001
AGESQ	1	293	22.10	0.0001
SUMMER	1	293	22.99	0.0001
CAMPAIGN	5	293	4.14	0.0012

EXPOSURE MODEL FOR DUST LEAD LOADINGS IN R&M AND CONTROL HOUSES
Excluding Initial Campaign Observations for Vacant Houses

Covariance Parameter Estimates (REML)

Cov Parm	Ratio	Estimate	Std Error	Z	Pr > |Z|
DID	3.13431181	0.18844154	0.04347274	4.33	0.0001
CHILDNUM(DID)	1.33194515	0.08007939	0.02447148	3.27	0.0011
Residual	1.00000000	0.06012214	0.00459296	13.09	0.0001

Model Fitting Information for LNBLOOD

Description	Value
Observations	488.0000
Variance Estimate	0.0601
Standard Deviation Estimate	0.2452
REML Log Likelihood	-213.052
Akaike's Information Criterion	-216.052
Schwarz's Bayesian Criterion	-222.307
-2 REML Log Likelihood	426.1050

Solution for Fixed Effects

Parameter	Estimate	Std Error	DDF	T	Pr > |T|	Alpha	Lower	Upper
INTERCEPT	1.58613616	0.12705926	33	12.48	0.0001	0.05	1.3276	1.8446
FACTOR1	0.12917892	0.03176318	342	4.07	0.0001	0.05	0.0667	0.1917
FACTOR2	0.03853343	0.01966196	342	1.96	0.0508	0.05	-0.0001	0.0772
AGE	0.02395806	0.00516876	342	4.64	0.0001	0.05	0.0138	0.0341
AGESQ	-0.00020167	0.00005118	342	-3.94	0.0001	0.05	-0.0003	-0.0001
SUMMER	0.20757774	0.03270684	342	6.35	0.0001	0.05	0.1432	0.2719
CAMPAIGN 24	-0.11691745	0.08736571	342	-1.34	0.1817	0.05	-0.2888	0.0549
CAMPAIGN 18	-0.05312616	0.07326497	342	-0.73	0.4689	0.05	-0.1972	0.0910
CAMPAIGN 12	-0.00840046	0.06022974	342	-0.14	0.8892	0.05	-0.1269	0.1101
CAMPAIGN 6	0.13252554	0.04913390	342	2.70	0.0073	0.05	0.0359	0.2292
CAMPAIGN 0	0.00000000	.	.	.	.	.	.	.

Tests of Fixed Effects

Source	NDF	DDF	Type III F	Pr > F
FACTOR1	1	342	16.54	0.0001
FACTOR2	1	342	3.84	0.0508
AGE	1	342	21.48	0.0001
AGESQ	1	342	15.53	0.0001
SUMMER	1	342	40.28	0.0001
CAMPAIGN	4	342	7.92	0.0001

EXPOSURE MODEL FOR DUST LEAD CONCENTRATIONS IN R&M AND CONTROL HOUSES
Excluding Initial Campaign Observations for Vacant Houses

Covariance Parameter Estimates (REML)

Cov Parm	Ratio	Estimate	Std Error	Z	Pr > |Z|
DID	2.98362252	0.17947811	0.04247077	4.23	0.0001
CHILDNUM(DID)	1.33585637	0.08035768	0.02441922	3.29	0.0010
Residual	1.00000000	0.06015443	0.00459870	13.08	0.0001

Model Fitting Information for LNBLOOD

Description	Value
Observations	488.0000
Variance Estimate	0.0602
Standard Deviation Estimate	0.2453
REML Log Likelihood	-211.664
Akaike's Information Criterion	-214.664
Schwarz's Bayesian Criterion	-220.918
-2 REML Log Likelihood	423.3272

Solution for Fixed Effects

Parameter	Estimate	Std Error	DDF	T	Pr > |T|	Alpha	Lower	Upper
INTERCEPT	1.61974105	0.12432703	33	13.03	0.0001	0.05	1.3668	1.8727
FACTOR1	0.13102199	0.02979734	342	4.40	0.0001	0.05	0.0724	0.1896
FACTOR2	0.03766021	0.01834571	342	2.05	0.0409	0.05	0.0016	0.0737
AGE	0.02367228	0.00513841	342	4.61	0.0001	0.05	0.0136	0.0338
AGESQ	-0.00019944	0.00005104	342	-3.91	0.0001	0.05	-0.0003	-0.0001
SUMMER	0.18969930	0.03208766	342	5.91	0.0001	0.05	0.1266	0.2528
CAMPAIGN 24	-0.15091130	0.08547613	342	-1.77	0.0784	0.05	-0.3190	0.0172
CAMPAIGN 18	-0.08516304	0.07114162	342	-1.20	0.2321	0.05	-0.2251	0.0548
CAMPAIGN 12	-0.03984081	0.05836050	342	-0.68	0.4953	0.05	-0.1546	0.0749
CAMPAIGN 6	0.09517201	0.04609245	342	2.06	0.0397	0.05	0.0045	0.1858
CAMPAIGN 0	0.00000000	.	.	.	.	.	.	.

Tests of Fixed Effects

Source	NDF	DDF	Type III F	Pr > F
FACTOR1	1	342	19.33	0.0001
FACTOR2	1	342	4.21	0.0409
AGE	1	342	21.22	0.0001
AGESQ	1	342	15.27	0.0001
SUMMER	1	342	34.95	0.0001
CAMPAIGN	4	342	6.79	0.0001

COMPARISON MODEL - R&M Houses
Children who had Baseline PbB < 15

Covariance Parameter Estimates (REML)

Cov Parm	Ratio	Estimate	Std Error	Z	Pr > |Z|
DID	1.93363859	0.13225319	0.03008152	4.40	0.0001
Residual	1.00000000	0.06839603	0.00658136	10.39	0.0001

Model Fitting Information for LNBLOOD

Description	Value
Observations	275.0000
Variance Estimate	0.0684
Standard Deviation Estimate	0.2615
REML Log Likelihood	-108.192
Akaike's Information Criterion	-111.192
Schwarz's Bayesian Criterion	-116.550
-2 REML Log Likelihood	216.3845

Solution for Fixed Effects

Parameter	Estimate	Std Error	DDF	T	Pr > |T|	Alpha	Lower	Upper
INTERCEPT	1.35659803	0.15475658	7	8.77	0.0001	0.05	0.9907	1.7225
AGE	0.02996828	0.00598453	207	5.01	0.0001	0.05	0.0182	0.0418
AGESQ	-0.00029219	0.00006647	207	-4.40	0.0001	0.05	-0.0004	-0.0002
SUMMER	0.16106596	0.04060877	207	3.97	0.0001	0.05	0.0810	0.2411
MALE	0.05974220	0.08131248	207	0.73	0.4633	0.05	-0.1006	0.2200
GROUP Level3	0.20280918	0.12747844	207	1.59	0.1132	0.05	-0.0485	0.4541
GROUP Level2	0.34150043	0.13320040	207	2.56	0.0111	0.05	0.0789	0.6041
GROUP Level1	0.00000000	.	.	.	.	.	.	.
CAMPAIGN 24	-0.22010031	0.09315551	207	-2.36	0.0191	0.05	-0.4038	-0.0364
CAMPAIGN 18	-0.14232238	0.08068985	207	-1.76	0.0792	0.05	-0.3014	0.0168
CAMPAIGN 12	-0.06326125	0.06853624	207	-0.92	0.3571	0.05	-0.1984	0.0719
CAMPAIGN 6	0.06628040	0.05744388	207	1.15	0.2499	0.05	-0.0470	0.1795
CAMPAIGN 2	0.04070795	0.05297315	207	0.77	0.4431	0.05	-0.0637	0.1451
CAMPAIGN 0	0.00000000	.	.	.	.	.	.	.

Tests of Fixed Effects

Source	NDF	DDF	Type III F	Pr > F
AGE	1	207	25.08	0.0001
AGESQ	1	207	19.32	0.0001
SUMMER	1	207	15.73	0.0001
MALE	1	207	0.54	0.4633
GROUP	2	207	3.49	0.0324
CAMPAIGN	5	207	3.56	0.0041

COMPARISON MODEL - R&M and Control Houses
Children who had Baseline PbB < 15

Covariance Parameter Estimates (REML)

Cov Parm	Ratio	Estimate	Std Error	Z	Pr > |Z|
DID	1.01347699	0.08550691	0.03555821	2.40	0.0162
CHILDNUM(DID)	0.46169433	0.03895309	0.02583045	1.51	0.1315
Residual	1.00000000	0.08436986	0.00737742	11.44	0.0001

Model Fitting Information for LNBLOOD

Description	Value
Observations	356.0000
Variance Estimate	0.0844
Standard Deviation Estimate	0.2905
REML Log Likelihood	-173.205
Akaike's Information Criterion	-176.205
Schwarz's Bayesian Criterion	-181.962
-2 REML Log Likelihood	346.4108

Solution for Fixed Effects

Parameter	Estimate	Std Error	DDF	T	Pr > |T|	Alpha	Lower	Upper
INTERCEPT	1.87710098	0.17929108	13	10.47	0.0001	0.05	1.4898	2.2644
AGE	0.02653713	0.00600230	257	4.42	0.0001	0.05	0.0147	0.0384
AGESQ	-0.00028800	0.00006572	257	-4.38	0.0001	0.05	-0.0004	-0.0002
SUMMER	0.21418178	0.04179803	257	5.12	0.0001	0.05	0.1319	0.2965
MALE	0.01041442	0.07991183	257	0.13	0.8964	0.05	-0.1470	0.1678
GROUP Modern	-1.20546783	0.15516792	257	-7.77	0.0001	0.05	-1.5110	-0.8999
GROUP Level3	-0.23663369	0.15288997	257	-1.55	0.1229	0.05	-0.5377	0.0644
GROUP Level2	-0.15166919	0.15737378	257	-0.96	0.3361	0.05	-0.4616	0.1582
GROUP Level1	-0.45579761	0.14541236	257	-3.13	0.0019	0.05	-0.7421	-0.1694
GROUP Abated	0.00000000	.	.	.	.	.	.	.
CAMPAIGN 24	-0.03533969	0.08726877	257	-0.40	0.6858	0.05	-0.2072	0.1365
CAMPAIGN 18	0.00392459	0.07463394	257	0.05	0.9581	0.05	-0.1430	0.1509
CAMPAIGN 12	0.03913664	0.06274015	257	0.62	0.5333	0.05	-0.0844	0.1627
CAMPAIGN 6	0.14885225	0.05188509	257	2.87	0.0045	0.05	0.0467	0.2510
CAMPAIGN 0	0.00000000	.	.	.	.	.	.	.

Tests of Fixed Effects

Source	NDF	DDF	Type III F	Pr > F
AGE	1	257	19.55	0.0001
AGESQ	1	257	19.20	0.0001
SUMMER	1	257	26.26	0.0001
MALE	1	257	0.02	0.8964
GROUP	4	257	21.93	0.0001
CAMPAIGN	4	257	3.81	0.0050

COMPARISON MODEL - R&M Houses
Children who had Baseline PbB $\geq$ 15

Covariance Parameter Estimates (REML)

Cov Parm	Ratio	Estimate	Std Error	Z	Pr > |Z|
DID	1.21556862	0.05944389	0.01895164	3.14	0.0017
Residual	1.00000000	0.04890213	0.00608623	8.03	0.0001

Model Fitting Information for LNBLOOD

Description	Value
Observations	172.0000
Variance Estimate	0.0489
Standard Deviation Estimate	0.2211
REML Log Likelihood	-42.9460
Akaike's Information Criterion	-44.9460
Schwarz's Bayesian Criterion	-48.0212
-2 REML Log Likelihood	85.8920

Solution for Fixed Effects

Parameter	Estimate	Std Error	DDF	T	Pr > |T|	Alpha	Lower	Upper
INTERCEPT	2.65095301	0.17929169	31	14.79	0.0001	0.05	2.2853	3.0166
AGE	0.00535426	0.00728763	129	0.73	0.4639	0.05	-0.0091	0.0198
AGESQ	0.00001480	0.00007896	129	0.19	0.8516	0.05	-0.0001	0.0002
SUMMER	0.16484531	0.04627217	129	3.56	0.0005	0.05	0.0733	0.2564
MALE	-0.01812614	0.06444864	129	-0.28	0.7790	0.05	-0.1456	0.1094
GROUP Level3	0.16085253	0.12592523	129	1.28	0.2038	0.05	-0.0883	0.4100
GROUP Level2	0.14887318	0.13212947	129	1.13	0.2620	0.05	-0.1125	0.4103
GROUP Level1	0.00000000	.	.	.	.	.	.	.
CAMPAIGN 24	-0.68255084	0.10016407	129	-6.81	0.0001	0.05	-0.8807	-0.4844
CAMPAIGN 18	-0.53920530	0.08209819	129	-6.57	0.0001	0.05	-0.7016	-0.3768
CAMPAIGN 12	-0.43420679	0.07085946	129	-6.13	0.0001	0.05	-0.5744	-0.2940
CAMPAIGN 6	-0.30088479	0.05896597	129	-5.10	0.0001	0.05	-0.4176	-0.1842
CAMPAIGN 2	-0.19077598	0.05741701	129	-3.32	0.0012	0.05	-0.3044	-0.0772
CAMPAIGN 0	0.00000000	.	.	.	.	.	.	.

Tests of Fixed Effects

Source	NDF	DDF	Type III F	Pr > F
AGE	1	129	0.54	0.4639
AGESQ	1	129	0.04	0.8516
SUMMER	1	129	12.69	0.0005
MALE	1	129	0.08	0.7790
GROUP	2	129	0.89	0.4145
CAMPAIGN	5	129	11.23	0.0001

COMPARISON MODEL - R&M and Control Houses
Children who had Baseline PbB ≥ 15

Covariance Parameter Estimates (REML)

Cov Parm	Ratio	Estimate	Std Error	Z	Pr > |Z|
DID	0.80243457	0.04445764	0.01378069	3.23	0.0013
Residual	1.00000000	0.05540345	0.00671681	8.25	0.0001

Model Fitting Information for LNBLOOD

Description	Value
Observations	182.0000
Variance Estimate	0.0554
Standard Deviation Estimate	0.2354
REML Log Likelihood	-51.0040
Akaike's Information Criterion	-53.0040
Schwarz's Bayesian Criterion	-56.1398
-2 REML Log Likelihood	102.0081

Solution for Fixed Effects

Parameter	Estimate	Std Error	DDF	T	Pr > |T|	Alpha	Lower	Upper
INTERCEPT	2.88795170	0.18860552	38	15.31	0.0001	0.05	2.5061	3.2698
AGE	0.00225921	0.00761214	132	0.30	0.7671	0.05	-0.0128	0.0173
AGESQ	0.00002938	0.00008244	132	0.36	0.7221	0.05	-0.0001	0.0002
SUMMER	0.16984762	0.05055427	132	3.36	0.0010	0.05	0.0698	0.2698
MALE	-0.01345613	0.06467768	132	-0.21	0.8355	0.05	-0.1414	0.1145
GROUP Level3	-0.03275697	0.10819035	132	-0.30	0.7625	0.05	-0.2468	0.1813
GROUP Level2	-0.02211512	0.11451278	132	-0.19	0.8472	0.05	-0.2486	0.2044
GROUP Level1	-0.15375419	0.13170533	132	-1.17	0.2451	0.05	-0.4143	0.1068
GROUP Abated	0.00000000	.	.	.	.	.	.	.
CAMPAIGN 24	-0.58541228	0.09193630	132	-6.37	0.0001	0.05	-0.7673	-0.4036
CAMPAIGN 18	-0.47100204	0.07576296	132	-6.22	0.0001	0.05	-0.6209	-0.3211
CAMPAIGN 12	-0.39288317	0.06606633	132	-5.95	0.0001	0.05	-0.5236	-0.2622
CAMPAIGN 6	-0.26653979	0.05527380	132	-4.82	0.0001	0.05	-0.3759	-0.1572
CAMPAIGN 0	0.00000000	.	.	.	.	.	.	.

Tests of Fixed Effects

Source	NDF	DDF	Type III F	Pr > F
AGE	1	132	0.09	0.7671
AGESQ	1	132	0.13	0.7221
SUMMER	1	132	11.29	0.0010
MALE	1	132	0.04	0.8355
GROUP	3	132	0.54	0.6544
CAMPAIGN	4	132	12.73	0.0001